Engineering Accreditation Commission
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PROGRAM SELF-STUDY REPORT
for

ELECTRICAL ENGINEERING

Submitted by

The United States Air Force Academy

June 2002

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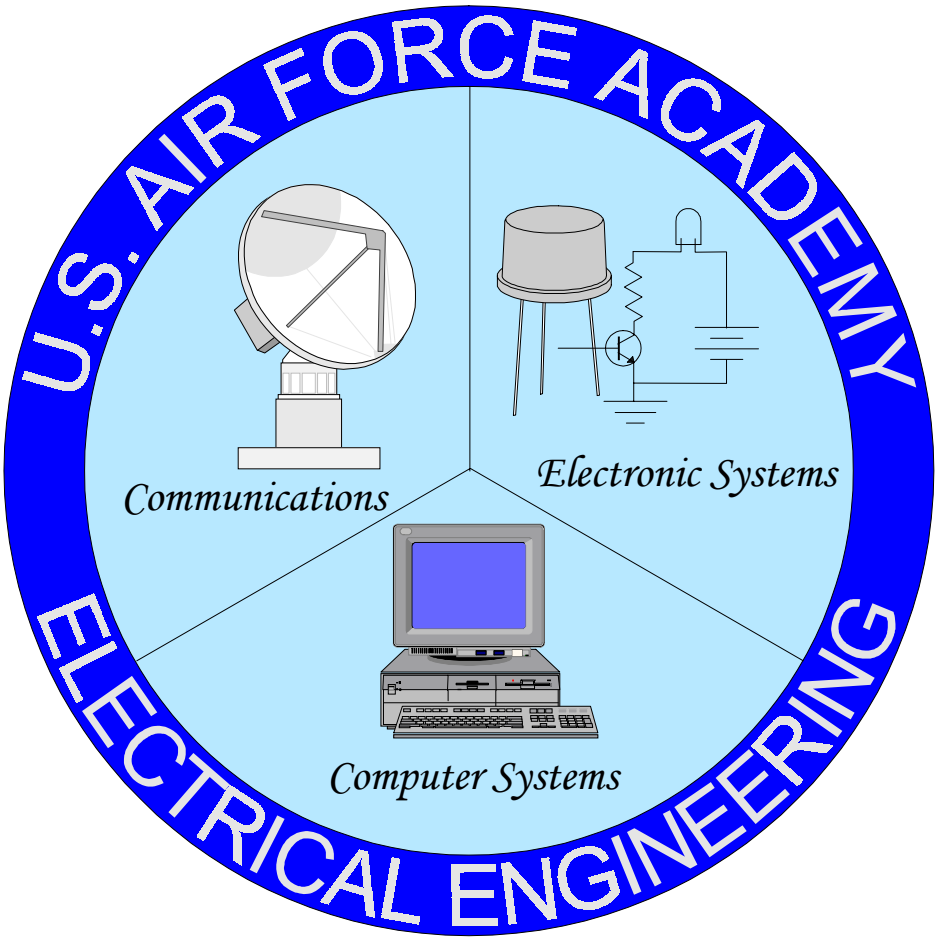
U.S. AIR FORCE ACADEMY
ELECTRICAL ENGINEERING
Communications
Electronic Systems
Computer Systems

PROGRAM SELF-STUDY REPORT

for review

of

ENGINEERING PROGRAMS

ELECTRICAL ENGINEERING

Submitted by

THE UNITED STATES AIR FORCE ACADEMY

JUNE 2002

to the

Engineering Accreditation Commission
Accreditation Board for Engineering and Technology

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PROGRAM SELF-STUDY REPORT

ELECTRICAL ENGINEERING

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Glossary of Terms and Acronyms

Term or Acronym	Description
AIC	Advisor in Charge
APS	Academic Program Summary
AY	Academic Year
CAP	Course Assessment Plan
Classes	Class correspondence according to: First Class = Senior rank, Second Class = Junior rank, Third Class = Sophomore rank, Fourth Class = Freshman rank
Class of xx	Denotes year of graduation, e.g., Class of 2003 graduates in May 2003
Core	The academic courses in Basic Sciences, Engineering, Humanities, and Social Sciences required of all cadets irrespective of major. Core currently consists of 31 courses: see USAFA Curriculum Handbook
Course Director	Faculty member in charge of a course within the electrical engineering program.
CSRP	Cadet Summer Research Program
DFR	Office of the Registrar, Dean of Faculty
Division Chief	Faculty member in charge of a discipline within the electrical engineering program.
DF	Dean of Faculty
DFCS	Department of Computer Science (Dean of Faculty, Comp Sci)
DFEE	Department of Electrical Engineering (Dean of Faculty, El Engr)
DoD	Department of Defense
ECEAB	Electrical and Computer Engineering Advisory Board
GPA	Grade Point Average
Majors Night	Job-Fair type function allowing undeclared cadets to preview academic disciplines at USAFA
NCA	North Central Association: Provides regional accreditation for the USAF Academy as an institution of higher education
PCO	Program Curricular Outcome (equivalent to ABET Program Educational Outcome). Statement that defines knowledge, skill, ability at the time of graduation.

Term or Acronym	Description
PIP	Process Improvement Principal. A member of the Assessment Committee responsible for Electrical and Computer Engineering Program review and ABET compliance.
POG	Program Operational Goal (equivalent to ABET Program Objective). Statement that defines observable ability of alumni approximately 2-3 years beyond graduation.
Skills Review	DFEE Assessment Instrument: Course Prerequisite Knowledge
TBD	To Be Determined
USAF	United States Air Force
USAFA	United States Air Force Academy

Program Self-Study Report
for
Electrical Engineering

A. Background Information

1. Degree Titles

Bachelor of Science in Electrical Engineering

2. Program Modes

As with the engineering unit as a whole, the electrical engineering program is offered in the day mode exclusively. No courses are offered in the evening, co-op, off-campus, or telecommunications modes.

3. Actions to Correct Previous Shortcomings

The last Engineering Accreditation Committee (EAC) visit was in 1996. There were no identified deficiencies or shortcomings in the Electrical Engineering program. The EAC did not identify any deficiencies common to all engineering programs at the United States Air Force (USAF) Academy.

4. Contact Information

Please direct questions on the USAF Academy Electrical Engineering program to the Department of Electrical Engineering's Director of Assessment or Department Head:

Director of Assessment

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B. Accreditation Summary

The USAF Academy has had a strong tradition of self examination and continuous improvement since it was established in 1954. In the early 1990s the focus shifted to outcomes-based assessment with a clearly defined set of educational outcomes developed by the faculty in 1994. The Department of Electrical Engineering developed goals and measurable objectives during the next few years with full participation by all faculty.

Using the EC2000 requirements as an additional input, the assessment processes were formalized in 1999. An overview of the program assessment process is shown in Figure 1.

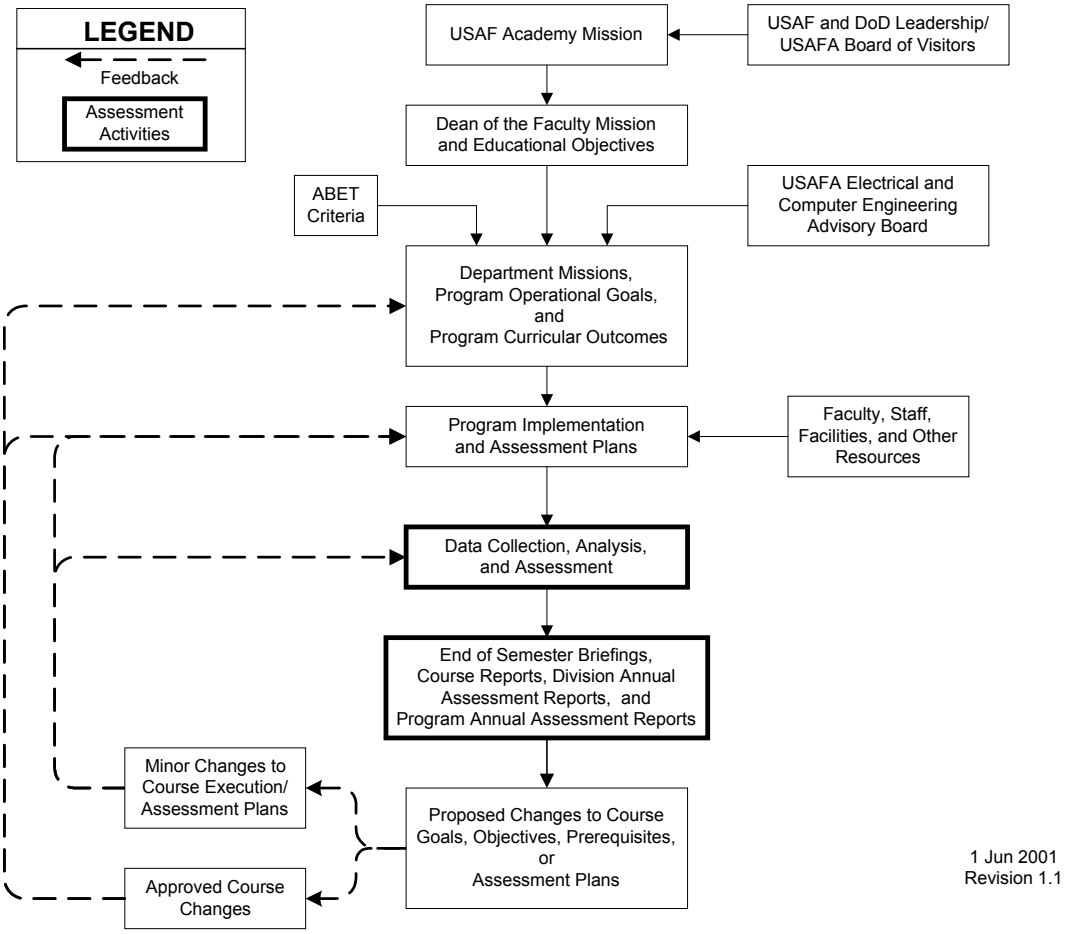

Figure 1. Electrical Engineering Assessment Process Overview

The Department of Electrical Engineering chose to base its primary assessment processes for the curricular outcomes on cadet achievements in individual courses. These are supplemented by surveys and examinations taken by the graduating class each year. As the development of the curricular outcomes and assessment processes progressed, the Department consulted with experienced ABET program evaluators.

The Department of Electrical Engineering also identified Supporting Goals and Objectives. They enumerate the requirements for providing faculty, monetary, and physical resources to properly support attainment of the program goals, curricular outcomes, and the other Department of Electrical Engineering goals. The achievement of the Supporting Goals and Objectives is assessed through a variety of methods. Assessing the supporting objectives measures the health of the administration of the Department and the electrical engineering program. Successfully recruiting, developing, and supporting faculty and staff ensure the human resources to implement the academic programs. Likewise, planning for and acquiring adequate facilities, supplies, and equipment is essential to support the delivery of the curriculum and faculty research.

The Department of Electrical Engineering is organized into administrative units called divisions which are responsible for the delivery, support, and assessment of their assigned courses on a daily basis. This structure involves all members of the faculty in assessment. The details of the assessment process are handled by the Director of Assessment who heads a standing committee of Process Improvement Principals.

In addition to highlighting the relationship of the USAF Academy mission to the Electrical Engineering Program Goals (Program Operational Goals), Figure 1 also illustrates how the program's constituents provide feedback for continuous improvement. In this process, the program goals reside at the top, along with the measurable outcomes (Program Curricular Outcomes) which define the desired attributes of our graduates at the end of their undergraduate academic experience. The electrical engineering program goals and outcomes are published on the department's internet and intranet sites, in the USAF Academy Catalog, "Major's Night" handouts, and annual faculty reference binders. Program goals and outcomes are also published in the department office and in each classroom.

The program goals and outcomes are supported by program objectives as well as division and course goals and objectives. The entire detailed assessment process is shown in the Electrical Engineering Program Assessment Flow Chart in Figure 2. This flow chart and the plans shown on it direct the activities of the instructors, division chiefs, and senior leadership as they execute the assessment process. Figure 2 also has been useful in training and in the orientation of new and returning faculty members.

The Electrical Engineering and Computer Engineering Program Assessment Plan describes the process of Figure 2 in detail and identifies responsible individuals for all tasks. It also includes the Electrical Engineering Program Assessment Schedule with the timelines of assessment activities for an entire assessment year. This schedule is organized so the tasks for each department role (instructor, course director, etc.) appear together so the schedules can be easily used to ensure timely completion of all assessment tasks. This schedule is published in the assessment plan and in the annual faculty reference binders. It has been determined that a schedule integrated into the MS®Outlook calendar program used by all faculty members would be very helpful and is planned for AY 2002-2003 implementation. This new schedule will ensure rapid and easy access for all department members.

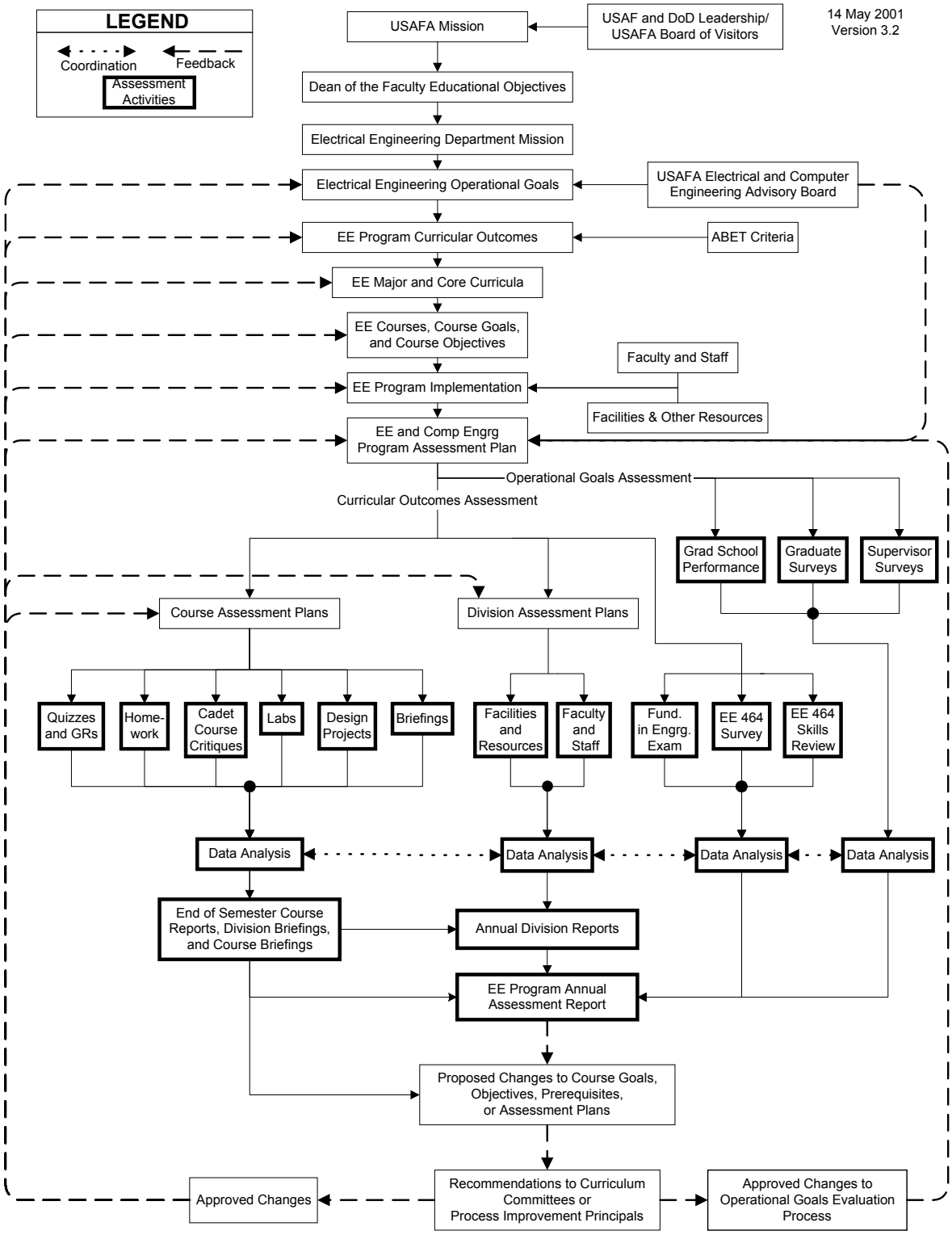

Figure 2. USAFA Electrical Engineering Program Assessment Process Flow

The divisions are responsible for the delivery, support, and assessment of their assigned courses on a regular basis. The Division Chiefs follow an assessment process that is portrayed in Figure 3. At this level, the course data and results are reviewed in terms of course sequences. Although course directors coordinate with the Course Directors of other courses as part of the normal course planning process, this sequence review provides input on how well the courses integrate to support the overall program outcomes.

Resources (faculty and facilities) are reviewed at the division level, so the divisions provide key inputs for the department assessment process. The division chiefs are members of the Department of Electrical Engineering Curriculum Committee which approves significant curricular changes. Changes that impact other departments must be approved by the Dean of Faculty Curriculum Committee.

Our course-based assessment requires attention to detail at the lowest level. To achieve this, a Course Director is designated for each course and is responsible for the administration of the course. The Course Directors and the Division Chiefs report assessment results at the end of each semester. The assessment reports at the end of each fall semester consist of:

- the Course Briefings for the upcoming spring semester
- the Course Assessment Reports for the just completed fall semester
- the Division Mid-Year Assessment Briefings

The assessment reports at the end of each spring semester consist of:

- the Course Briefings for the upcoming fall semester
- the Course Assessment Reports for the just completed spring semester
- the Division Year-End Assessment Briefings
- the Division Year-End Assessment Reports

The results of the course and division reports along with the Department-level assessments are incorporated into the Program Annual Assessment Report before 1 August. The department is briefed on the results at the beginning of the fall semester.

The assessment year for the electrical engineering program is from 1 June to 31 May. All reports for the prior assessment year are completed by 1 August. All raw and reduced data as well as assessment reports are stored in a Program Assessment Repository according to the Program Assessment Repository Schema.

More detail on any of the subjects addressed in this Self Study can be found in the "Assessment Plan for Electrical Engineering and Computer Engineering Programs." The Departments of Electrical Engineering and Computer Science created this plan to document our assessment and continuous process improvement processes. All plans, templates, schedules, and flow diagrams referenced or presented herein exist as separate documents that are linked to the Assessment Plan.

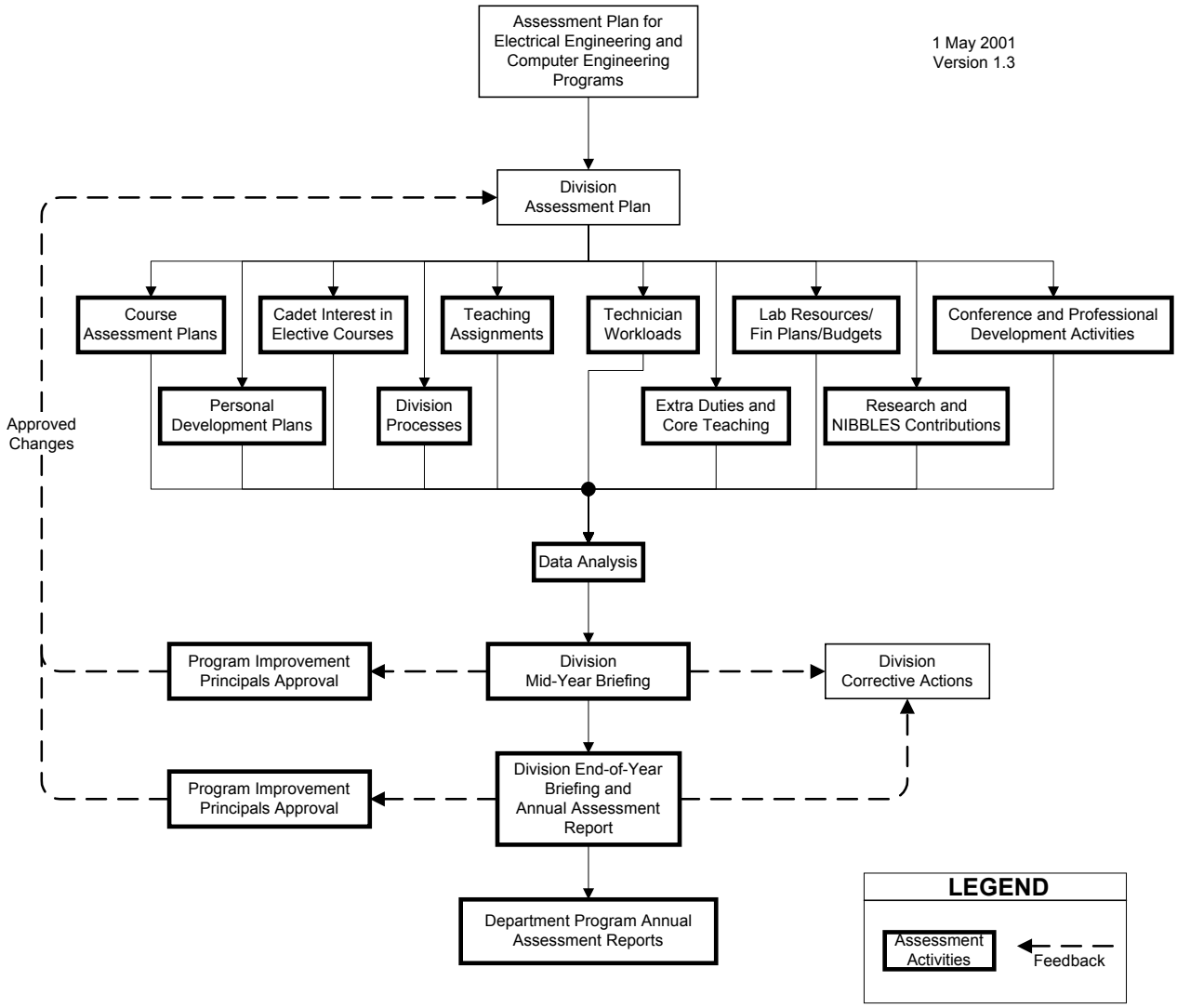

Figure 3. USAFA Department Electrical Engineering Divisional Assessment Process

The Department of Electrical Engineering assessment process described above is implemented by an outstanding faculty dedicated to excellence in undergraduate engineering education. The electrical engineering program is designed and implemented to provide a challenging curriculum and supportive environment for every cadet. The well-defined assessment processes ensure the curriculum, facilities, personnel, and support are available to meet the Program Operational Goals and Program Curricular Outcomes. Regular internal and external feedback are analyzed and used to continually improve these processes.

For more information about the Department of Electrical Engineering and its assessment processes, please see our web site at http://www.usafa.af.mil/dfee/.

1. Students

The quality and performance of the students and graduates are important considerations in the evaluation of an engineering program. The institution must evaluate, advise, and monitor students to determine its success in meeting program objectives. The institution must have and enforce policies for the acceptance of transfer students and for the validation of courses taken for credit elsewhere. The institution must also have and enforce procedures to assure that all students meet all program requirements.

The admissions criteria used by the Academy are set by the Secretary of the Air Force. On entering, cadets must be 17 to 23 years of age, of high moral character, and qualified for service in the U.S. Air Force. The following factors are evaluated: Prior Academic Achievement (high school and college), College Board and Aptitude and Achievement scores or American College Testing Scores, Athletic and Non-athletic Activities Score, Candidate Fitness Test, Medical Examination, and Selection Panel Scores. A weighted Selection Composite Score is computed for each applicant. This score is a summary of factors that best indicate potential for success at the Academy and a high probability of a successful career in the Air Force.

Successful applicants must rank in the top 40 percent of their high school class, must score at least 580 on the SAT verbal aptitude exam and 560 on the math aptitude exam, or must score at least 24 on the ACT English exam and 25 on the math exam. In addition, scores of 24 for the ACT Reading and 25 for the ACT Science Reasoning are also required. For the past six years, the average ACT score was 28.92 and the average SAT score was 1282.

As of 1 April 2002, 82 cadets were enrolled in the electrical engineering major. In the Class of 2002, there were 22 cadets. The projected number of majors for the Class of 2003 is 26 and 21 cadets from the Class of 2004. As of 31 May 2002, 13 cadets in the Class of 2005 signed up for the major. The number of majors reaches its peak each Spring, after registration for the Fall Semester, when all sophomores must have declared their major. Based on the interest shown at our annual major's night, we expect a typical enrollment after the 2002 Fall registration period.

1.1 Evaluation, Advising, and Monitoring

A three-level evaluation, advising, and monitoring system is used to ensure electrical engineering cadets meet all set program requirements. This system involves the faculty academic advisor, the program Advisor-in-Charge (AIC), and the Office of the Registrar Class Coordinators.

1.1.1 Evaluation

When a cadet decides to declare the electrical engineering major, the cadet first meets with the department Advisor-in-Charge. The Advisor-in-Charge evaluates the cadet's ability to succeed in electrical engineering by reviewing the cadet's current Academic Program Summary (APS) which reflects courses completed and grades earned as the cadet progresses through a program. If this evaluation indicates the cadet can complete the electrical engineering program, the Advisor-in-Charge helps the cadet choose one of the electrical engineering areas of concentration.

Using the Office of the Registrar's cadet database program, Q2i, the Advisor-in-Charge declares the cadet an electrical engineering major, assigns a department faculty advisor, and develops the cadet's electrical engineering academic program.

1.1.2 Advising

All faculty members serve as academic advisors. The Office of the Registrar provides an Advisor Handbook to each new instructor. Advisor training is included as part of the orientation required of all new and returning faculty members and advisor training is also accomplished annually at the department's back-to-school offsite. In addition, the Office of the Registrar provides a handbook entitled "ABCs of Academics" to each cadet to maximize their participation in the advising process.

Cadets meet with their advisors at least once each semester to review course loading, current progress, and update their Academic Program Summary using Q2i. Faculty members are encouraged to discuss areas of concern with the student and faculty advisors at any time during the semester.

1.1.3 Monitoring

Members of the faculty's senior leadership meet with all electrical engineering majors at the beginning of each academic year. These class meetings allow the cadets an opportunity to ask questions of the faculty and also give the faculty the opportunity to discuss things coming up during that year (i.e., scholarships, IEEE student chapter recruiting and meetings, amateur radio club, curriculum changes, Fundamentals of Engineering Examination, etc.).

Throughout the academic year, the faculty advisor is responsible, with the cadet, for monitoring the cadet's academic program and performance. Faculty advisors review the cadet's performance at mid-semester and at the end of the semester. If a cadet is deficient, the advisor consults with the cadet's instructors and advises the cadet on corrective actions. Deficient cadets are placed on academic probation at mid- or end-of-semester grading cycles by the Class Academic Review Committee chaired by a department head and administered by the Class Coordinators. The advisor assists the cadet in developing a "get-well" program and monitor's the cadet's progress. Faculty members are encouraged to discuss areas of concern with the faculty advisors at any time during the semester.

In addition to monitoring the cadets' academic program and progress, the faculty meets prior to the beginning of each semester to "de-conflict" major assignments for electrical engineering courses taken during the junior and senior years. This "de-confliction" matrix is provided to each cadet to assist in their workload management efforts.

1.2 Transfer and Validation

Since the Air Force Academy is a mandatory four-year residence program, very few cadets request transfer credit for electrical engineering courses. The policy of the Air Force Academy with respect to advanced standing is stated in USAFA Regulation 537-21, Transfer and Validation Credit and Fourth Class Registration. Transfer credit is only awarded for corresponding college level courses taken at a college, university, or secondary school. A grade of "B" or higher must be achieved for award of transfer credit. Transfer credits may be applied toward graduation requirements, but not toward residency requirements.

Occasionally a cadet completes one semester in a USAFA-sponsored exchange program. In these instances, the cadet's entire program is closely evaluated by the advisor, the Advisor-in-Charge, and the Deputy Department Head. Transfer credit is awarded only after verification that the course content is substantially the same. The majority of classes taken in the exchange semester are equivalents for core courses rather than major's courses.

A cadet who wishes to receive transfer credit for electrical engineering courses must submit a request to the Deputy Department Head through the Advisor-in-Charge. Material reviewed for transfer determination includes course description, text used, and chapter coverage. If any questions persist concerning curriculum content after an interview with the cadet, the institution from which the course was taken is contacted.

A cadet must have at least eight semesters in residence at USAFA. A semester spent in USAFA-sponsored exchange programs counts as a semester in residence. A cadet must take at least 136 semester hours at USAFA (including those completed in USAFA-sponsored exchange programs) to satisfy residency requirements, regardless of semester hours transferred and validated. Courses which do not fulfill residency requirements include those validated or transferred, courses carrying no semester hour credit, pass/fail courses, core preparation courses, and courses failed.

The Office of the Registrar organizes and supervises the evaluation of courses for transfer credit. Granting of credit for electrical engineering courses is monitored by the Deputy Department Head, Lieutenant Colonel Cameron H.G. Wright, a sequential tour (tenured) faculty member with eight years experience at the Academy.

1.3 Program Requirements Verification

Substitutions for courses in the electrical engineering program are extremely rare. A formal request for waiver must be submitted and approved by the advisor, the Advisor-in-Charge, and the Electrical Engineering Department Head. Each of these individuals must confirm that the substitute course fulfills the program requirements satisfied by the original course. Finally, if the course is a core course, the Vice Dean must approve the request.

When the advisor makes changes to the cadet's program, Q2i forwards changes to the Advisor-in-Charge to review and approve. The Advisor-in-Charge checks each Academic Program Summary again to ensure all prerequisites and course requirements are satisfied.

When the Advisor-in-Charge approves the changes, the Academic Program Summary is automatically submitted to the Office of the Registrar where it is subjected to a formal computer review (Academic Graduation Check) for compliance with the Academy's graduation requirements and for the electrical engineering program requirements.

Responsibility for ongoing program review rests with the individual academic advisors, the program Advisor-in-Charge (AIC), and the Office of the Registrar. Class Coordinators and Records Managers in the Office of the Registrar are assigned to each class (year) of cadets. Class Coordinators are responsible for monitoring and approving changes to the academic program. Records Managers run the Academic Graduation Check software program after computer-updating of the academic program to ensure graduation requirements are met. The first class (senior) Records Manager ultimately confirms, prior to graduation, that all degree requirements for a graduating senior have been satisfied.

Since all possible combinations of electrical engineering electives that satisfy program graduation requirements also satisfy Accreditation Board for Engineering and Technology (ABET) requirements, completion of an ABET accredited program is assured. Detailed information on the electrical engineering curriculum is available to cadets in the Academy Curriculum Handbook. An example Academic Program Summary and the associated computer-generated Academic Graduation Check are provided in Appendix I-D.

2. Program Operational Goals (POGs)

> *Each engineering program for which an institution seeks accreditation or re-accreditation must have in place:*
> *(a) detailed published educational objectives that are consistent with the mission of the institution and these criteria*
> *(b) a process based on the needs of the program's various constituencies in which the objectives are determined and periodically evaluated*
> *(c) a curriculum and processes that ensure the achievement of these objectives*
> *(d) a system of ongoing evaluation that demonstrates achievement of these objectives and uses the results to improve the effectiveness of the program*

The name chosen for the attributes that the Department of Electrical Engineering expects its graduates to have two to three years after graduation is Program Operational Goals (POGs). Program Operational Goals are therefore the U.S. Air Force Academy equivalent of ABET "Educational Objectives." The word "operational" emphasizes that the expected behavior will be measured after the graduates are on active duty in an "operational" assignment. The development of the Program Operational Goals was initiated by the faculty, most of whom are USAF officers well aware of operational requirements, and confirmed by our Electrical and Computer Engineering Advisory Board. The faculty then ensured there was a way to evaluate whether or not the Program Operational Goals are achieved. The details of these measurements and the assessment of the results will be presented later in this section.

Based on the evaluation of the last two assessment cycles, our cadets, faculty, and external constituents are familiar with our Program Operational Goals. They are published on the department's internet and intranet sites, in the USAF Academy catalog, in all classrooms, and front office. Our program goals have been externally validated and all were achieved. The overall continuous improvement processes implemented by the Department of Electrical Engineering require periodic review of the Program Operational Goals as outlined in the Assessment Plan for Electrical and Computer Engineering Programs.

2.1 Background

The United States Air Force Academy (USAFA) has a long history of continuous improvement to its curriculum. To further ensure the faculty efforts were properly coordinated and supportive of the Academy's mission, the most senior academic administrators met throughout the academic year 1992 - 1993 and reached a consensus on seven educational outcomes expected of the academic experience at the USAF Academy.

In the summer of 1994, an Educational Outcomes Assessment Working Group was formed. Initially comprised of 20 faculty volunteers, the group eventually involved over 50 faculty and cadets. They assessed the contributions of each of the 35 required core courses to the achievement of three of the outcomes. Following this institutional lead, the Department of Electrical Engineering, as well as the other academic departments, developed a self-assessment program. By 1997, the department senior faculty had concluded that the initial efforts at self-assessment had provided significant benefit, but did not result in a sustainable process. In 1998 the Department of Electrical Engineering (DFEE) performed a systematic review of the assessment processes with three goals in mind:

1. Improve the clarity of the mission statement beyond the general intent to support the overall faculty educational outcomes.
2. Provide complete and more narrowly focused goals.
3. Improve precision in stating measurable objectives to support the goals.

This review involved all faculty members and kept in mind that the EC2000 criteria requires accurate, reliable data on all aspects of program performance. After much discussion and several iterations, all faculty members agreed on a hierarchical assessment structure based on mission statements, goals, and measurable objectives. This structure has been implemented and its processes have been continuously improved ever since.

2.2 Development of Program Operational Goals (POGs)

The electrical engineering program exists to support the mission of the USAF. From the USAF mission flows the missions of the Air Force Academy, the Dean of the Faculty, and the departments/programs. This hierarchy of missions is listed below.

The USAF mission is:

To defend the United States through control and exploitation of air and space.

The USAF Academy mission is to:

Inspire and develop outstanding young men and women to become Air Force officers with knowledge, character, and discipline; motivated to lead the world's greatest aerospace force in service to the nation.

The Dean of Faculty's mission is to:

Inspire and educate cadets and faculty to serve our nation with integrity in peace and war.

The Department of Electrical Engineering's mission is:

To produce graduates motivated and able to excel as officers in a technologically sophisticated Air Force.

Using the hierarchy of mission statements above, and following the structure suggested by ABET, the Department of Electrical Engineering faculty drafted Program Operational Goals that describe the desired performance of our graduates two to three years after graduation. These goals are:

Electrical Engineering Program Operational Goals

Two to three years after graduation the Department of Electrical Engineering expects its graduates to be officers who:

1. *Possess breadth of integrated, fundamental knowledge in the basic sciences, engineering, humanities, and social sciences; and depth of knowledge in Electrical Engineering.*
2. *Can communicate effectively.*
3. *Can work effectively with others.*
4. *Are independent thinkers and learners.*
5. *Can apply their knowledge and skills to solve Air Force engineering problems, both well and ill defined.*
6. *Know and practice their ethical and professional responsibilities as embodied in the United States Air Force core values.*

The faculty realized that ABET's intent is for a program's constituents (the cadets, the potential employers of the graduate, the graduates, and the faculty) to establish the Program Operational Goals. However, at the USAF Academy many faculty members are graduates, and the faculty can also be considered potential employers. This situation occurs because the Air Force assigns qualified active duty officers as faculty members for relatively short terms (three to four years). These officers come from, then return to, USAF organizations that often have USAF Academy graduates assigned. Thus, on assignments prior or subsequent to teaching, it is likely that faculty members will have graduates working for them. It was for these reasons that the faculty was comfortable drafting and establishing the initial validity of the Program Operational Goals. The Program Operational Goals were also validated by the USAF Academy Electrical and Computer Engineering Advisory Board discussed in the next section.

2.3 Program Constituency and Feedback

There has always been informal feedback from the USAF constituency regarding performance of USAF Academy graduates. This process was formalized by establishing a USAF Academy Electrical and Computer Engineering Advisory Board that meets at the USAF Academy every year. In addition, supervisor and graduate surveys have been implemented to validate the Program Operational Goals by evaluating the performance of our graduates a few years after graduation. New faculty members are surveyed as they arrive in the Department of Electrical Engineering from operational USAF assignments. Finally, the success of program graduates is also assessed when they attend graduate school. Thus, our constituency consists of those who hire our graduates (USAF supervisors and higher level leadership), faculty members (the military faculty all come from the operational Air Force), alumni, and our cadets.

The USAF Academy Electrical and Computer Engineering Advisory Board is comprised of eight to ten individuals who are first- or second-line supervisors of graduates who have been assigned to engineering jobs within the USAF. Advisory Board membership is determined by examining USAF assignment records and/or USAF Academy Association of Graduates

records to determine which USAF organizations have the largest concentrations of program graduates. Care is taken to ensure adequate representation of both electrical and computer engineers. The membership of the Advisory Board will be reviewed every three years to ensure that it remains representative of the distribution of graduates.

The Advisory Board meets with both the Electrical Engineering and Computer Engineering programs' leadership once a year at the USAF Academy. The agenda is designed to solicit maximum quantitative data, as well as subjective opinions from Board members regarding their experience with our graduates. In addition, the Program Operational Goals, program assessment processes, and results from the previous assessment cycle are reviewed with the Board.

2.4 Ensuring Achievement of the Program Operational Goals Through the Assessment Processes

The Assessment Processes in the Electrical Engineering Department use several methods to determine the achievement of the Program Operational Goals. Through survey analysis, feedback from the Electrical and Computer Engineering Advisory Board (ECEAB), review of graduate school success, and measurement of the Program Curricular Outcomes, all Program Operational Goals were attained for the past two assessment cycles. The following sections discuss the data used, success criteria, data analysis and assessment processes, and assessment results. It concludes with an example of closing the loop in our assessment cycle.

2.4.1 Program Operational Goals Data Collection

The achievement of the Program Operational Goals is assessed mainly through surveys to the constituencies (graduates, USAF supervisors, and faculty). Feedback obtained from the Advisory Board, graduate school success, and assessment of the measurable Program Curricular Outcomes are also used.

At the beginning of each calendar year, the Department of Electrical Engineering administers a survey to graduates and their supervisors. The same survey is administered to new military faculty soon after they arrive in the Department of Electrical Engineering to take advantage of their recent USAF experience. These surveys query the respondents to indicate how well they feel the graduates meet our Program Operational Goals, solicit written comments, and ask respondents to suggest changes if they think the Program Operational Goals are not a complete and correct set of operational goals. Responses to the surveys are stored in a database; however, survey data for the first two assessment cycles was sparse. Process improvement efforts include finding a more accurate means of identifying the graduates and their supervisors and making the surveys web-based.

Graduate school records for department sponsored graduates are also collected and analyzed as a measure of how well graduates were prepared for an educational experience at another institution. Those who attend graduate school under other sponsorships/scholarships are tracked as well.

The attainment of the Program Curricular Outcomes is used as a measure of achievement of the Program Operational Goals, for if the Program Curricular Outcomes are not achieved; it is reasonable to expect that two to four years later there will be evidence that the Program Operational Goals are not being achieved

2.4.2 Program Operational Goals Success Criteria

On the assessment surveys a six-point scale is used to determine if the program is successfully meeting its Program Operational Goals. Responses to the surveys of four, five, or six (Slightly Agree, Agree, and Strongly Agree, respectively) for a positive question and one, two, or three for a negative question (Strongly Disagree, Disagree, and Slightly Disagree, respectively) are considered satisfactory. When evaluating graduates pursuing advanced education, a graduate school success rate near 100 percent is expected for those who achieved at least a 3.0/4.0 grade-point average at the USAF Academy.

The mapping of the Program Curriculum Outcomes to the Program Operational Goals is presented in Table 1 (Section 3.2, Page 21) and the success criteria for these outcomes are presented in Table 3 (Section 3.4 Page 23).

2.4.3 External Feedback Data Analysis and Assessment

The collected survey data and feedback from the Advisory Board are analyzed to determine:

- the degree to which graduates feel their education and the curriculum prepared them for their job challenges,
- the degree to which supervisors think graduates are performing to the levels described in the Program Operational Goals,
- the degree to which the Advisory Board agrees the curriculum adequately prepares graduates to perform to Program Operational Goals standards after they graduate,
- if the survey responses indicate changes to the curriculum or Department operations are desirable,
- if Advisory Board questions and comments suggest changes to the curriculum or Department operations, and
- if the survey questions and the Advisory Board meeting agenda were effective in soliciting an accurate response that measures the Program Operational Goals.

The raw and reduced data collected/generated is stored in the Program Assessment Repository. The Program Assessment Repository resides on a network server to ensure backups are routinely accomplished. If any assessment files are maintained on desktop computers, these files are uploaded regularly according to the published assessment schedule.

2.4.4 Program Operational Goals Assessment Results

A summary of the Advisory Board findings and survey results is provided in the Program Annual Assessment Report. The Program Operational Goals were validated by the Advisory Board and supervisors of our graduates. Twenty four questions were asked on the survey with only two having less than the desired 4.0 average. These two and all with less than a 4.3 score were reviewed with board members. After reviewing the results from the supervisor's survey and of the Program Curricular Outcomes assessment, the board agreed that the Program Operational Goals were attained, but recommended changing the wording of two of the Program Operational Goals. This was considered by the faculty and accomplished.

Between 1996 and 2001, eleven electrical engineering majors attended graduate school at institutions such as Iowa State University, University of Iowa, University of Texas at Austin, Utah State University, University of Washington, and MIT. All successfully completed their programs in the time allotted by the USAF.

All Program Curricular Outcomes were met. Supporting evidence is included in Section 3.5 (Page 32). The AY 2000-2001 and AY 2001-2002 Program Annual Assessment Reports which summarize the processes, data, results, and recommendations will be available during the evaluation visit.

2.4.5 Proof that the Program Operational Goals Assessment Process is Effective

The following information is taken (unedited) from the document *"Minutes of Electrical and Computer Engineering (ECE) Advisory Board Meeting – 10 November 2000"*

2. Discussion: Col Neal welcomed the advisory board members and explained the reason for the meeting which was to obtain approval from the advisory board of the Program Operational Goals (POGs) for the Electrical Engineering and Computer Engineering degree programs and discuss the results of the surveys the board members returned.

    a. Lt Col Wright reviewed the previous Accreditation Board for Engineering and Technology (ABET) criteria and introduced the new EC2000 accreditation criteria that focus on continuous improvement with assessment processes. Gen Royer explained that accreditation is desired by the Air Force because of the Air Force Specialty Code requirements. Col Neal explained that by meeting the minimum standards set by ABET for all US engineering programs, our programs are competitive with any other accredited school which helps USAFA recruitment. The Dean strongly supports accreditation. Accreditation helps for professional licensing and also serves as a third party check on the quality of our programs. The Electrical Engineering and the Computer Engineering Program Operational Goals were presented to the board.

b. Gen Royer briefed the survey results. The board had comments on some wording and all responses with less than a 4.0 (out of 5.0) average were reviewed.
   1) "*Officers who are independent learners*." This POG addresses the motivation and toolset for cadets to continue their learning after graduation. Since they need to "think" critically as well as "learn," the advisory board recommended we change to read "independent thinkers and learners." DFEE and DFCS agreed to consider this change.
   2) "*Officers who know their ethical and professional responsibilities as embodied in the United States Air Force core values of 'Integrity First, Service before Self, and Excellence in all we do."*" This POG addresses the graduate's knowledge of ethical and professional responsibilities. Board members would prefer a more active goal, e.g., "know and practice." DFEE and DFCS agreed to consider modifying with words such as "exhibit" or "practice."
   3) "*Academy-educated electrical engineering graduates have a sufficient grounding in radio frequency circuit theory, devices, systems and propagation.*" Reviewed because of one very low score. All agreed that the wording indicates a "sufficient" level of understanding, which depends on the job. Therefore, this question should be answered in the context of the organization. Survey instructions will be modified to reflect this.
   4) "*Academy-educated electrical engineering graduates keep current with Air Force issues."* All agreed that graduates should keep current with Air Force issues, but the board expressed concerns about the departments' impact in this area. DFEE explained that while we depend heavily on the core program to meet this need, all courses try to use Air Force issues as examples at least once a month. The upper level classes use Air Force articles/issues in class at least once a month. No change will be made to this question.
   5) "*Academy-educated electrical engineering graduates accept the challenges of Air Force engineering without complaining about perceived differences in the practice of engineering in the civilian sector."* The consensus was that graduates have unrealistic expectations for their jobs. The Academy can better inform them about the types of jobs available upon graduation. The ECE advisory board agreed to help with displays for majors night and guest speakers for our majors courses and professional society student chapter meetings.

3. Action Items (Responsible Individual, Expected Completion Date):
   c. <u>POG modification</u> – DFEE and DFCS will consider rewording the two POGs as indicated in paragraphs 2.b.1 and 2.b.2 and report results to the ECE Advisory Board (Gen Royer, 8 Dec 00)

      As reported in the 2 February 2001 document *"MEMORANDUM FOR ELECTRICAL and COMPUTER ENGINEERING ADVISORY BOARD"* with the Subject line *"Status of Action Items from Electrical and Computer Engineering (ECE) Advisory Board Meeting held 10 November 2000"*, this action item was cleared. Below is the unedited material from that document.

1. The following list is the Action Items from our Fall 2000 meeting and their status. Where appropriate and when so noted, the results of the Actions Items are included as attachments.
   c. POG modification – DFEE and DFCS will consider rewording the two POGs as indicated in paragraphs 2.b.1 and 2.b.2 (of the minutes) and report results to the ECE Advisory Board (Gen Royer, 8 Dec 00)
   STATUS: Suggested changes were considered and adopted. Reworded Program Operational Goals are attached. Action Item completed with this memorandum.

2.5 Ensuring Achievement of the Program Operational Goals Through the Curriculum

During the establishment and initial validation of the Program Operational Goals, the faculty reviewed the curriculum based on Air Force requirements previously identified, the operational experience of the faculty, the curriculum provided at the other service academies and several top civilian universities, and the ABET program criteria. The current curriculum was determined to be satisfactory in meeting the needs of the newly established program goals.

The Program Operational Goals listed in Section 2.2 are fully supported by the electrical engineering curriculum. Regarding breadth, the rich core requirements spanning humanities, social sciences, basic sciences, and engineering courses must be completed by all cadets. The depth of knowledge in electrical engineering (EE) is supported by the EE major requirement that includes courses in circuits, electronics, digital logic, microprocessors, power, communication systems, and electromagnetics. Communication skills are supported by the various presentations and papers required in a large number of courses. The many team-oriented activities required at a military service academy support the goal of working effectively with others, and the numerous course assignments support the goal of developing independent thinkers and learners. All the engineering courses support the goal of developing the ability to solve Air Force engineering problems. Ethical and professional responsibilities are explored in a variety of courses, including many engineering courses, a required philosophy course, and a required law course.

The Program Operational Goals are fully supported by the full spectrum of the electrical engineering curriculum coupled with the extensive required core curriculum. These goals have been thoughtfully developed, validated externally and internally, and are an integral part of the overall continuous process improvement strategy of the electrical engineering program at the U.S. Air Force Academy.

3. Program Curricular Outcomes (PCOs) and Assessment

Engineering programs must demonstrate that their graduates have:
(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Each program must have an assessment process with documented results. Evidence must be given that the results are applied to the further development and improvement of the program. The assessment process must demonstrate that the outcomes important to the mission of the institution and the objectives of the program, including those listed above, are being measured. Evidence that may be used includes, but is not limited to the following: student portfolios, including design projects; nationally-normed subject content examinations; alumni surveys that document professional accomplishments and career development activities; employer surveys; and placement data of graduates.

The name chosen for the attributes that the Department of Electrical Engineering expects its graduates to have upon graduation is Program Curricular Outcomes (PCOs). The word "curricular" emphasizes the source of the expected behavior. The word "outcomes" follows from common academic usage and the ABET terminology of Criterion 3. Program Curricular Outcomes are our equivalent to the ABET "Program Outcomes."

The Program Curricular Outcomes describe the desired attributes of our electrical engineering graduates at the end of their undergraduate academic experience. Great care was taken to ensure these Program Curricular Outcomes support the Dean of Faculty Educational Outcomes and the electrical engineering Program Operational Goals. In addition, the development of the Program Curricular Outcomes ensured there was a way to measure each of them. The processes previously described were used to develop and assess the Program Curricular Outcomes. The application of these results to produce program improvements are described later in this section.

Based on our first two annual formal assessment processes (AY 00-01 and 01-02), our cadets, faculty, and external constituents are familiar with our Program Curricular Outcomes. Based on the Course Assessment Reports from 1996 to 2000 and the formal evaluation in our last two assessment cycles, all Program Curricular Outcomes were achieved. The mapping between our program's outcomes and ABET Criterion 3 shows all ABET requirements are also met. The documented continuous improvement processes implemented by the Department of Electrical Engineering ensure a systematic focus on data collection, analysis of data collected, and use of each analysis to assess the effectiveness of the program in meeting its stated outcomes and goals.

In this section the Program Curricular Outcomes are listed and related to the Program Operational Goals as well as the outcome requirements of ABET Criterion 3. The objective criteria used to measure attainment of the Program Curricular Outcomes so our graduates ultimately achieve the Program Operational Goals are then discussed. The data used to measure attainment of our

Program Curricular Outcomes is presented and analyzed. The use of these results to improve the electrical engineering program is demonstrated. Finally, the materials that will be available during the visit to demonstrate achievement of the Program Operational Goals and Program Curricular Outcomes are described.

3.1 Development of the Program Curricular Outcomes (PCOs)

Traditional emphasis on course assessment provides most assessment data for the Program Curricular Outcomes; however, the Program Curricular Outcomes were created in a top-down fashion. Using the Program Operational Goals, the Dean of Faculty Educational Outcomes, previously developed program curricular outcomes, and previous departmental Unit Self Assessment reports, the faculty drafted a set of outcomes. Through a succession of department meetings, the outcomes were combined, refined, and finally agreed upon. The electrical engineering Program Curricular Outcomes are:

Electrical Engineering Program Curricular Outcomes

Each Electrical Engineering graduate shall demonstrate satisfactory:

1. *Application of the fundamental concepts of electrical engineering to solve engineering problems.*
2. *Laboratory techniques including procedures, recording, and analysis.*
3. *Design, fabrication, and test techniques.*
4. *Use of contemporary electrical engineering analysis, design, and test tools.*
5. *Written and oral communication skills.*
6. *Knowledge of ethical and professional responsibilities.*
7. *Breadth and depth of knowledge and skills in electrical engineering, computer science, mathematics, and other disciplines necessary to effectively identify and solve the types of complex, multidisciplinary problems they will face as Air Force engineers.*
8. *Knowledge of the benefits and the skills needed to engage in life-long learning.*
9. *Ability to be effective multidisciplinary team members.*
10. *Skills to be an independent learner while knowing when to seek help.*
11. *Knowledge of the role of Air Force engineering officers in our global society.*
12. *Knowledge of contemporary social, political, military, and engineering issues.*

For several years, the Department of Electrical Engineering has used one or more Program Curricular Outcomes at the annual faculty offsite to focus an annual curriculum review.

- In 1999, the faculty reviewed all the supporting course objectives to ensure they were applicable and measurable.
- In 2000, the focus was on the contemporary software tools used by cadets. The requirements for all courses were reviewed which allowed all course directors to determine the amount of support provided by tool use in pre-requisite courses. It also allowed the faculty to review other software tools, although the consensus was to continue using the current tools.
- In 2001, the faculty reviewed how the Program Curricular Outcomes support the ABET Criterion 3 requirements.

The faculty will continue to periodically review the Program Curricular Outcomes and the methods used to support them.

3.2 Relationship of Program Curricular Outcomes to Program Operational Goals

The electrical engineering Program Curricular Outcomes relate to the Program Operational Goals as shown in Table 1 below:

Table 1. Electrical Engineering Program Curricular Outcomes Support of the Program Operational Goals

Program Operational Goals (POGs) / Program Curricular Outcomes (PCOs)	Breadth	Communication	Teamwork	Independent	Application	Ethical/ Professional
1 - Fundamentals	X				X	
2- Lab Techniques	X				X	
3 - Design/Fab/Test	X				X	
4 - Contemporary Tools	X				X	
5 - Communication		X	X			
6 - Ethics/Profession						X
7 - Breadth & Depth	X				X	
8 - Life Long Learning				X		
9 - Team Members		X	X		X	
10 - Independent Learner				X		
11 - Engr Role in Society						X
12 - Contemporary Issues	X			X	X	

Care was taken to ensure that there are a minimum of two Program Curricular Outcomes supporting each Program Operational Goal. The matrix is reviewed for accuracy and completeness annually by the department's standing assessment committee, the Process Improvement Principals (PIPs). Although the assessment of the Outcomes does not in itself provide direct feedback that the Goals are being met, they serve as indicators as to whether or not we expect the Goals to be met by our graduates a few years after graduation.

3.3 Support of the ABET Criterion 3

Each of the Program Curricular Outcomes supports at least one of the ABET Criterion 3 items as shown in Table 2.

Table 2. Support of ABET Criterion 3 by the Electrical Engineering Program Curricular Outcomes

Program Curricular Outcomes \ ABET Criterion 3		a	b	c	d	e	f	g	h	i	j	k
Each Electrical Engineering graduate shall demonstrate satisfactory:												
1	Application of the fundamental concepts of electrical engineering to solve engineering problems.					X						
2	Laboratory techniques including procedures, recording, and analysis.		X									
3	Design, fabrication, and test techniques.		X	X								
4	Use of contemporary electrical engineering analysis, design, and test tools.											X
5	Written and oral communication skills.							X				
6	Knowledge of ethical and professional responsibilities.						X					
7	Breadth and depth of knowledge and skills in electrical engineering, computer science, mathematics, and other disciplines necessary to effectively identify and solve the types of complex, multidisciplinary problems they will face as Air Force engineers.	X										
8	Knowledge of the benefits and the skills needed to engage in life-long learning.											X
9	Ability to be effective multidisciplinary team members.				X							
10	Skills to be an independent learner while knowing when to seek help.									X		
11	Knowledge of the role of Air Force engineering officers in our global society.								X			
12	Knowledge of contemporary social, political, military, and engineering issues.										X	

The individual Course Assessment Plans, which can be accessed through the "Assessment Plan for Electrical Engineering and Computer Engineering Programs," and the course syllabi provide the details of the course activities that are used to assess cadet achievement of the ABET Criterion 3 items. Survey questions and course objectives that provide the data that is

used to assess achievement of the Program Curricular Outcomes (and thereby ABET Criterion 3 individual factors) are outlined in the next section.

3.4 Support of the Program Curricular Outcomes

The vast majority of the data used to assess the achievement of the electrical engineering Program Curricular Outcomes comes from the individual Course Assessment Reports. Other sources of data are the Fundamentals of Engineering Exam, USAF Academy Graduation Survey, El Engr 464 Skills Review, and the El Engr Major's Exit survey. Their contributions are discussed in this section.

For each metric that is measured to determine success in meeting the Program Curricular Outcomes there are established success criteria as listed in Table 3. Ten of the 12 Program Curricular Outcomes are measured by three metrics; the other two are measured by four. The metrics may have multiple other metrics that flow up to Table 3 (e.g. for PCO #1, 63 course objectives are used) or a single measure such as the pass rate on the Fundamentals of Engineering exam.

Table 3. Measurement Metrics and Success Criteria for the Electrical Engineering Program Curricular Outcomes

Program Curricular Outcomes (PCOs)	Measurement Metrics AY 01-02	Success Criteria
1 - Fundamentals	• 63 individual course objectives • Fundamentals of Engr Exam • USAFA Graduation Survey • EE Major's Exit Survey	• ≥54 (85%) met, PIPs confirm • Pass rate ≥ national average • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question
2- Lab Techniques	• 9 individual course objectives • EE Major's Exit Survey • El Engr 464 Skills Review	• ≥7 (78%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 73 %
3 - Design/Fab/Test	• 13 individual course objectives • EE Major's Exit Survey • El Engr 464 Skills Review	• ≥11 (85%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 73 %
4 -Contemporary Tools	• 6 individual course objectives • EE Major's Exit Survey • El Engr 464 Skills Review	• ≥5 (83%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 73 %
5 - Communication	• 12 individual course objectives • USAFA Graduation Survey • EE Major's Exit Survey	• ≥10 (83%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question
6 - Ethics/ Profession	• 2 individual course objectives • USAFA Graduation Survey • EE Major's Exit Survey	• ≥1 (50%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question

Program Curricular Outcomes (PCOs)	Measurement Metrics AY 01-02	Success Criteria
7 - Breadth & Depth	• 3 individual course objectives • Fundamentals of Engrg Exam • USAFA Graduation Survey • EE Major's Exit Survey	• ≥2 (67%) met, PIPs confirm • Pass rate ≥ national average • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question
8 - Life Long Learning	• 4 individual course objectives (secondary) • USAFA Graduation Survey • EE Major's Exit Survey	• ≥3 (75%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question
9 - Team Members	• 2 individual course objectives • USAFA Graduation Survey • EE Major's Exit Survey	• ≥1 (50%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question
10 - Independent Learner	• 7 individual course objectives • USAFA Graduation Survey • EE Major's Exit Survey	• ≥6 (85%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question
11 - Engr Role in Society	• 1 individual course objective • USAFA Graduation Survey • EE Major's Exit Survey	• ≥1 (100%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question
12 - Contemporary Issues	• 6 individual course objectives • USAFA Graduation Survey • EE Major's Exit Survey	• ≥5 (83%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question

While we have established quantitative success criteria for the number of course objectives that must be met for each Program Curricular Outcome to be successful, there is still a subjective, informed decision that must be made.

If course objectives that support a common Program Curricular Outcome were not met or were marginally met, the Electrical Engineering Director of Assessment, in consultation with the Process Improvement Principals, determines the impact on the achievement of the affected outcome. For example, the course objective for PCO #11 (knowledge of the role of Air Force engineering officers in our global society) was marginally met. The Director of Assessment and Process Improvement Principals reviewed the results of the two surveys and determined that cadets had unrealistic expectations of their first Air Force assignments. After some discussions, cadets did in fact understand what their roles would be. The outcome was therefore considered achieved, but needing close observation. The same process would be used in the case where multiple questions on a survey support a single Program Curricular Outcome.

In addition to the Course Directors' assessment of cadet performance (to ensure they satisfy course objectives), cadets have the opportunity to give the Course Director feedback on how clearly they think objectives were presented. The mechanism for this feedback is an (anonymous) institutional Course Critique they complete for every course at the end of the

semester. These critiques also contain general questions related to course-content and quality-of-instruction, along with a department's specific questions if desired. The critique's purpose is to give cadets the opportunity to offer their opinions without fear of retribution. Instructors see only composite results, and those only after grades have been assigned. Written comments are attached to the numerical results. The criterion for success for these critiques is a score of 4.0 or better on a six-point scale. A score lower than 4.0 triggers action to correct the condition.

3.4.1 Program Curricular Outcomes Support by Course Objectives

As can be seen in Figure 2 (Page 4), the assessment of the curriculum is largely based on the course assessment process. The overall course assessment process has three major elements:

- Course briefs before the semester starts
- Running the course throughout the semester
- Course Assessment Reports at the end of the semester.

This course assessment process, shown below in Figure 4, is based on well defined, configuration controlled Course Assessment Plans (CAPs) which detail the course objectives, how each is assessed, and the success criteria for each objective.

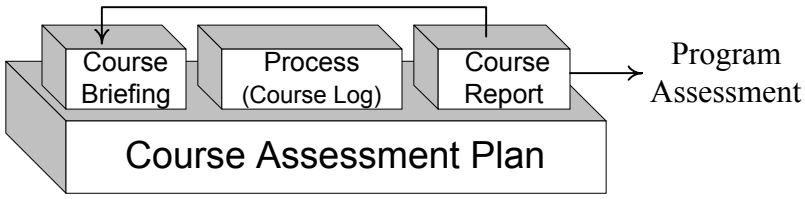

Figure 4. Electrical Engineering Course Assessment Process Steps

The Course Assessment Plans were created over the period of two years and provide a record of the course description, pre-requisites by topic, objectives, contribution of the course to the Program Curricular Outcomes, methods for assessing the course and specific success criteria, and course contributions to the engineering practice components (i.e., environmental, political, social, health and safety, and economic considerations, manufacturability and sustainability, contemporary issues, and engineering ethics.) Course Directors maintain a log throughout the semester to record observations and use this along with the Course Assessment Plan to assess the course in a Course Assessment Report. To close the loop on recommendations and observations, this report must be read by the next Course Director and any recommendations for changes must be addressed during the Course Briefing for the next offering.

The Course Assessment Plan provides a roadmap for the Course Director, but does not include details of implementation, such as the number of lessons devoted to a topic, arrangement of topics, textbook, etc. This allows the Course Director flexibility in running the course - as long as the course objectives are measured as outlined and met. The list of current Course Assessment Plans can be found in Attachment B of the

Assessment Plan for Electrical Engineering and Computer Engineering Programs. Individual Course Assessment Plans are linked in the above attachment. The results of the course assessment are reported at the end of the semester according to the Department of Electrical Engineering Course Assessment Report Template, which can be found through the "Assessment Plan for Electrical Engineering and Computer Engineering Programs."

The Course Assessment Report addresses whether course objectives were met. If there is a problem meeting a course objective, the Course Assessment Report defines the problem and recommends corrective action. The next time the course is offered, the course director will brief the entire department on the prior problem, planned corrective action, and an assessment method to determine if the planned corrective action is successful. At the end of each assessment year, the Course Assessment Reports are summarized in the Electrical Engineering Program Annual Assessment Report.

Table 4 shows the relationships between individual course objectives and the Program Curricular Outcomes. In this table, the number of objectives for the course are in parentheses after the course number. The number of these objectives that support a given Program Curricular Outcome is listed in that outcome's column. Since an objective may support multiple outcomes, the sum of a given row may exceed the total number of objectives for that course.

Table 4. Support of the Electrical Engineering PCOs by the Course Objectives

Program Curricular Outcomes (PCOs) / Course and #Objectives	1-Fundamentals	2- Lab Techniques	3 - Design/Fab/Test	4 - Contemporary Tools	5 - Communication	6 - Ethics/Profession	7 - Breadth & Depth	8 - Life Long Learning	9 - Team Members	10 - Independent Learner	11 - Engr Role in Society	12 - Contemporary Issues
Signals & Systems Courses												
EE 231 (4) Electrical Circuits & Systems I	3	1	1	3			3					
EE 332 (8) Electrical Circuits and Systems II	7		3	1	1		1					
EE 333 (7) Continuous-Time Signals and Linear Systems	6		1	4	1		2					
EE 434 (4) Discrete-Time Signals and Systems	3		3	3	1		2					
Engr 311 (5) Electrical Power Systems	3				1		3		1			
Electronic Systems Courses												
EE 321 (5) Electronics I	4	1	4	2	1		2			2		
EE 322 (7) Electronics II	5	5	5	1	1							
EE 473 (4) Intro to CMOS VLSI Circuit Design	4		4	4	1		4					2
EE 495 (3) Special Topics - Audio Amplifier Design	3	1	2	2	1		1					
Digital Systems Courses												
EE 281 (9) Introductory Digital Systems	6	5	4	4	1		1					
EE 382 (8) Microcomputer Programming	6	3	3	6	2		3					
EE 383 (7) Microcomputer System Design I	3	2	5	1	1		1					

Program Curricular Outcomes (PCOs) / Course and #Objectives	1-Fundamentals	2- Lab Techniques	3 - Design/Fab/Test	4 - Contemporary Tools	5 - Communication	6 - Ethics/Profession	7 - Breadth & Depth	8 - Life Long Learning	9 - Team Members	10 - Independent Learner	11 - Engr Role in Society	12 - Contemporary Issues
EE 387 (7) Introduction to Robotic Systems	6		2		1		4					
EE 485 (4) Computer Architecture	4		1	3	2		1					3
Communications Courses												
EE 443 (4) Electromagnetics	4		1	2	1							
EE 444 (5) Applied Field Theory	4	1	1	2	2		1					
EE 447 (4) Communications Systems I	3	2		3	1		1					
EE 448 (4) Communications Systems II	4	1	2	2	1		2					
Project Oriented Courses												
EE 463 (4) Design Project Techniques	1	1	2	2	3	2	1			1	1	1
EE 464 (4) Design Project	3	2	3	3	1		3	4		4		4
Engr 410 Engineering Systems Design									X	X		

3.4.2 Support by Fundamentals of Engineering Exam

Course data is supplemented with the results achieved by the Electrical Engineering majors who take the annual Fundamentals of Engineering (FE) exam. The Fundamentals of Engineering Exam is not mandatory, but cadets are encouraged to take it and assessment funds are made available to cover the exam costs for majors in accredited engineering programs. Results for each subject area are analyzed and compared to institutional, state, and national norms when possible. The desired range is within 5% of these norms.

3.4.3 Program Curricular Outcomes Support by USAF Academy Graduation Survey

The USAF Academy Graduation Survey is administered by the Department of Behavioral Science and Leadership. These survey results are used to supplement the other data collected by the department. Summary data for each question in the categories of pride in accomplishments, mentoring, perceived accuracy ratings, academic policy, core course contributions, library resources, character development, military programs, opportunities, athletic programs, and preparation to serve are provided to each department with comparison data from the previous two classes. Departmental data is also provided in comparison to other departments along with cadet comments.

3.4.4 Program Curricular Outcomes Support by El Engr 464 Skills Review

All electrical engineering majors take a comprehensive El Engr 464 Skills Review. This skills review is an open-ended troubleshooting exercise to test the cadets ability to find problems in circuits and isolate the problem to a specific component. While the El Engr 464 Skills review is normally meant to remind cadets of basic hardware skills important to the design project experience, it was used in AY 01-02 as a measure of the adequacy of our laboratory instructional program. This two-hour test directly measures the achievement of the following Program Curricular Outcomes (all aspects of PCO #2 and the test portions of PCO #3 and PCO #4):

2. *Laboratory techniques including procedures, recording, and analysis.*
3. *Design, fabrication, and test techniques.*
4. *Use of contemporary electrical engineering analysis, design, and test tools.*

The Skills Review is administered near the beginning of the eighth semester so remedial instruction may be given if required prior to the cadets starting construction and testing of their culminating design project. Cadets' basic skills are scored in six categories:

- Interpret: the ability of the cadet to understand the circuit schematic, simulation data and intended operation of the circuit.
- Analysis: the quality of the circuit analysis process described in the cadet's submission.
- Data: the quality of the data recorded in the response.
- Equipment: the level of demonstrated skill in use of the laboratory equipment.

- Conclusions: the correctness and quality of the conclusions.
- Alterations: the condition of the circuit after completion of the exercise.

Results of the Skills Review are analyzed, and common errors/shortcomings are identified. This information is passed to the El Engr 321 and El Engr 322 Course Directors who work with the El Engr 464 Course Director to determine what type of adjustments, if any, are necessary. These results are also reported in the El Engr 464 Course Assessment Report and the Program Annual Assessment Report.

3.4.5 Program Curricular Outcomes Support by El Engr Major's Exit Survey

All electrical engineering majors complete an Electrical Engineering Major's Exit Survey, which can be found through the "Assessment Plan for Electrical Engineering and Computer Engineering Programs," during their last semester El Engr 464 capstone design course. The survey results reflect each cadet's view of his or her ability to perform and supplement the other assessment results. Table 5 below illustrates the support of the Electrical Engineering Program Curricular Outcomes by the Electrical Engineering Major's Exit Survey. The raw and reduced data are stored in the Program Assessment Repository along with the reports.

Table 5. Support of the Electrical Engineering PCOs by the Electrical Engineering Major's Exit Survey

Program Curricular Outcomes (PCOs) / Survey Questions	1-Fundamentals	2- Lab Techniques	3 - Design/Fab/Test	4 - Contemporary Tools	5 - Communication	6 - Ethics/Profession	7 - Breadth & Depth	8 - Life Long Learning	9 - Team Members	10 - Independent Learner	11 - Engr Role in Society	12 - Contemporary Issues
1 - 2	X											
3 - 5		X										
6 - 9			X									
10 - 11				X								
12 - 13						X						
14 - 18							X					
19 - 24								X				
25 - 29									X			
30 - 32										X		
33 - 34											X	
35 - 40												X
41 - 42					X							

3.5 Results Supporting Achievement of the Program Curricular Outcomes

The "Assessment Plan for Electrical Engineering and Computer Engineering Programs" has been in use for the past two years. Analysis of the data from these past two years clearly indicates that all twelve Program Curricular Outcomes have been met (Table 6). For prior years there are Course Assessment Reports available that show the achievement of course objectives for each offering of every course and data from previous surveys is also available.

Table 6. Program Curricular Outcomes Assessment Results Summary

Program Curricular Outcomes (PCOs)	Measurement Metrics AY 01-02	Success Criteria	Results*
1 - Fundamentals	• 63 individual course objectives • Fundamentals of Engr Exam • USAFA Graduation Survey • EE Major's Exit Survey	• ≥54 (85%) met, PIPs confirm • Pass rate ≥ national average • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question	• 97% met for AY 00-01, PIPs confirmed • Achieved -classes of 96, 98, 99, 00, and 01 • Achieved • Achieved
2- Lab Techniques	• 9 individual course objectives • EE Major's Exit Survey • El Engr 464 Skills Review	• ≥7 (78%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 73 %	• 100% met for AY 00-01, PIPs confirmed • Achieved • Achieved - 01 and 02
3 - Design/Fab/ Test	• 13 individual course objectives • EE Major's Exit Survey • El Engr 464 Skills Review	• ≥11 (85%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 73 %	• 98% met for AY 00-01, PIPs confirmed • Achieved • Achieved - 01 and 02
4 -Contemporary Tools	• 6 individual course objectives • EE Major's Exit Survey • El Engr 464 Skills Review	• ≥5 (83%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 73 %	• 95% met for AY 00-01, PIPs confirmed • Achieved • Achieved - 01 and 02
5 - Communication	• 12 individual course objectives • USAFA Graduation Survey • EE Major's Exit Survey	• ≥10 (83%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question	• 82% met for AY 00-01, PIPs confirmed • Achieved • Achieved

Program Curricular Outcomes (PCOs)	Measurement Metrics AY 01-02	Success Criteria	Results*
6 - Ethics/ Profession	• 2 individual course objectives • USAFA Graduation Survey • EE Major's Exit Survey	• ≥1 (50%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question	• 100% met for AY 00-01, PIPs confirmed • Achieved, but 98 and 99 were Neutral + • Achieved
7 - Breadth & Depth	• 3 individual course objectives • Fundamentals of Engr Exam • USAFA Graduation Survey • EE Major's Exit Survey	• ≥2 (67%) met, PIPs confirm • Pass rate ≥ national avg • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question	• 93% met for AY 00-01, PIPs confirmed • 99, 00, and 01 • Achieved
8 - Life Long Learning	• 4 individual course objectives (secondary) • USAFA Graduation Survey • EE Major's Exit Survey	• ≥3 (75%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question	• 100% met for AY 00-01, PIPs confirmed • Achieved • Achieved
9 - Team Members	• 2 individual course objectives • USAFA Graduation Survey • EE Major's Exit Survey	• ≥1 (50%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question	• 100% met for AY 00-01, PIPs confirmed • Achieved • Achieved
10 - Independent Learner	• 7 individual course objectives • USAFA Graduation Survey • EE Major's Exit Survey	• ≥6 (85%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question	• 100% met for AY 00-01, PIPs confirmed • Achieved • Achieved
11 - Engr Role in Society	• 1 individual course objective • USAFA Graduation Survey • EE Major's Exit Survey	• ≥1 (100%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question	• 100% met for AY 00-01, PIPs confirmed • Achieved, but 98 and 99 were Neutral + • Achieved
12 - Contemporary Issues	• 6 individual course objectives • USAFA Graduation Survey • EE Major's Exit Survey	• ≥5 (83%) met, PIPs confirm • Average score ≥ 4.0 each question • Average score ≥ 4.0 each question	• 100% met for AY 00-01, PIPs confirmed • Achieved • Achieved

*Results from the AY 2000-2001 assessment cycle include all objectives. In response to recommendations to require sufficient, but not excessive assessment efforts, the objectives for each course were streamlined and weighted for the AY 2001-2002 and subsequent cycles. This reduced the number of individual course objectives required to support each outcome. These results will be available in the AY 2001-2002 Program Annual Assessment Report.

The following sections summarize the analysis of data from Course Director assessments, cadet course critiques, the Fundamentals of Engineering Exam, USAF Academy Graduation Survey, El Engr 464 Skills Review, and the El Engr Major's Exit Survey. The data supporting these results will be available during the ABET evaluation visit.

3.5.1 Results from Course Assessments

The Electrical Engineering Program Annual Assessment reports contain the low level assessment analysis that produces the course objectives support for the Program Curricular Outcomes data. All Course Assessment Reports for the last six years have been analyzed and reviewed with the appropriate Course Directors and Division Chiefs. A review of these end-of-course reports indicated that while assessment methods were clearly supported with course/cadet data, the report template did not require the Course Director to close the loop by specifically stating whether the objective was achieved, marginally achieved, or not achieved. The end-of-course report template was modified in August 2001 to require this for future offerings. A detailed analysis shows that since there are multiple course objectives that were successfully met supporting each of the Program Curricular Outcomes (Table 6 on pages 31-32), all outcomes were achieved using the course objective assessments.

The Fall 2000 and Spring 2001 Course Assessment Reports were analyzed in more detail and summarized in the AY 2000-2001 Electrical Engineering Program Annual Assessment Report. The Fall 2001 and Spring 2002 Course Assessment Reports are currently under review and will be summarized in the AY 2001-2002 Program Annual Assessment Report. All these reports will be available during the evaluation visit.

For AY 2000-2001, over 94% of all course objectives were achieved and less than 5% were marginally achieved. The remaining objectives were for Engr 410, Engineering Systems Design. This course is not an Electrical Engineering Department responsibility and there was no specific request for information from the Course Director or instructors. Informal feedback from the instructors in the department who taught this course indicates that the objectives were met.

The course report and assessment plan review for the AY 2000-2001 report indicated that the then current Program Curricular Outcomes vs. Course Objective matrix should be updated. In response, new Course Assessment Plans were approved in January 2002 with a faculty-wide review in May 2002 during the Fall 2002 Course Briefs. The Process Improvement Principals adopted a method for indicating which course objectives are primary measures for the Program Curricular Outcomes and which are optional. These

details are listed in Appendix I-B as a preface to the course syllabi (pages 103-106). This will allow Course Directors to have some flexibility in collecting assessment data without adversely affecting the assessment of the Program Curricular Outcomes. The new matrix was used to determine the course samples of student work necessary to support the ABET requirements for the Fall 2002 visit.

3.5.2 Results from Course Critiques

Course Objectives drive the planning and execution of instruction for the courses in our electrical engineering curriculum. Thus, it is very important that cadets know the objectives. Cadet feedback on the clarity of objectives is reviewed every semester. A course is flagged if the cadets' scores are below 4.0 (Slightly Agree). All courses were above the department minimums in this area and a summary of the average results is shown in Figure 5. It can be easily seen that the electrical engineering program is a leader in the Engineering Division in this area. In fact, the program has led or matched the division for nine of the ten semesters.

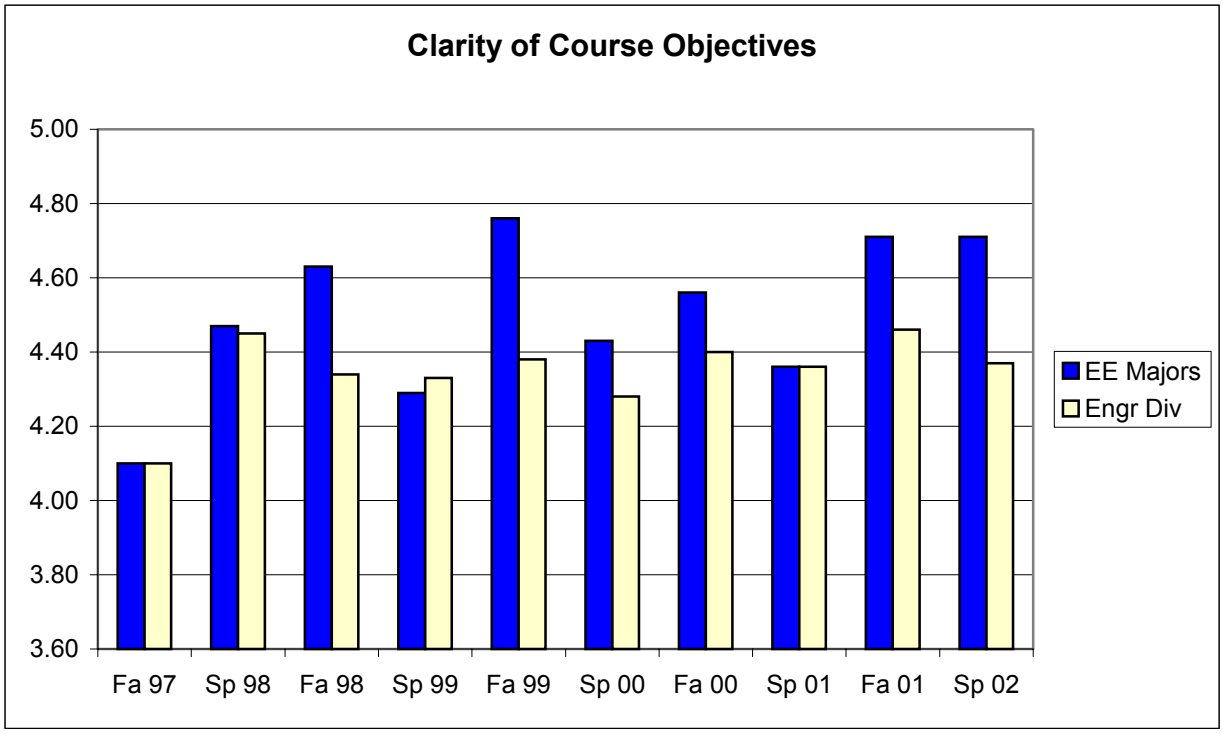

Figure 5. Cadet Critique Feedback on the Clarity of Course Objectives

Although course objectives are listed in the syllabus for every course, we found that it is imperative that instructors explain the objectives to the cadets and refer to them throughout the semester. Otherwise, the cadet perception is affected since they sometimes cannot see how the work they are doing relates to the objectives.

Cadet feedback on the degree to which the objectives were met is also reviewed every semester. A course is flagged if the cadets' scores are below 4.0 (Slightly Agree). All courses were above the department minimums in this area and a summary of the results is shown in Figure 6. It can be easily seen that the electrical engineering program is a leader in the Engineering Division. This data supports the assessment reports by the Course Directors.

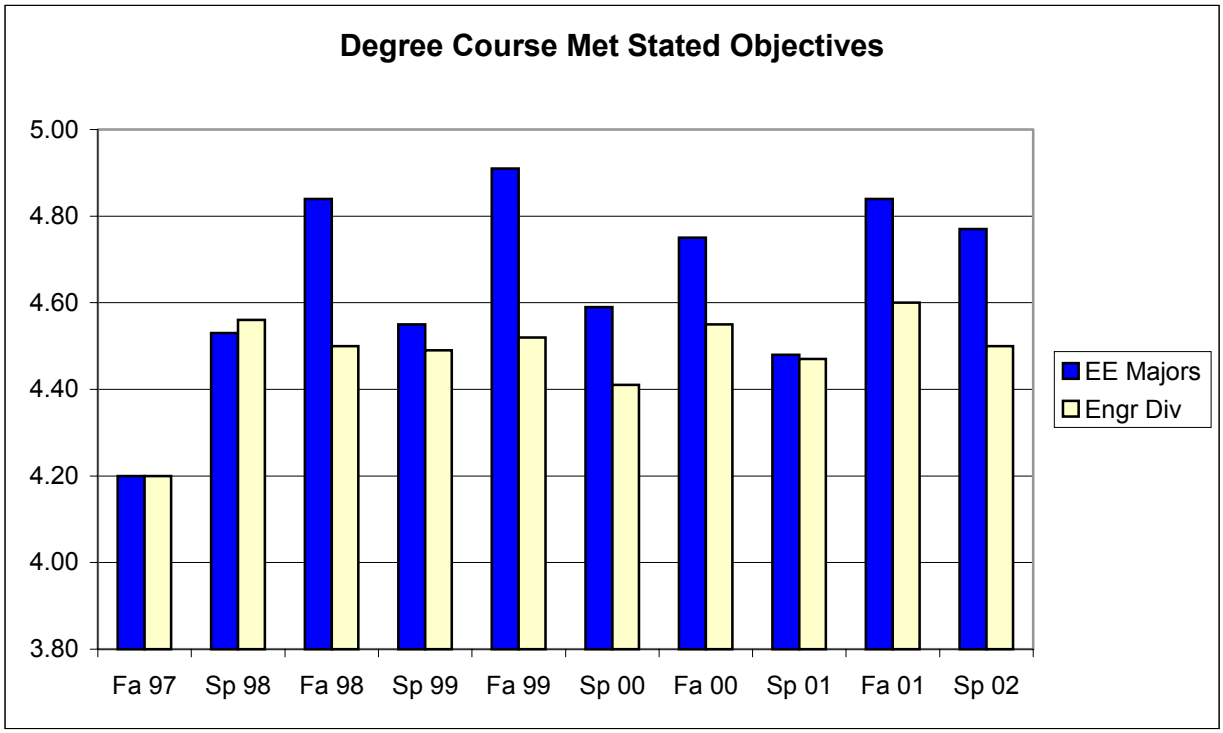

Figure 6. Cadet Critique Feedback on the Degree to Which Courses Met Stated Objectives

3.5.3 Results from the Fundamentals of Engineering Exam

All seniors are encouraged to take the Fundamentals of Engineering Examination. The results achieved are presented in Table 7.

Table 7. Results from the FE Exam Supporting the Program Curricular Outcomes

Year	Number of Cadets	% of Majors	EE Pass Rate	USAFA Pass Rate	Statewide Pass Rate	National Pass Rate
2002	2 of 24	8.33 %	TBD	TBD	TBD	TBD
2001	8 of 11	72.73 %	100 %	--	77 %	80 %
2000	14 of 27	51.85 %	100 %	100 %	82 %	81 %
1999	15 of 24	62.50 %	93.33 %	84.4 %	84.7 %	81.3 %
1996	11 of 25	44.00 %	100 %	89 %	77 %	81%

Since the FE exam is a multiple choice, individual effort exam, the results are only used to assess the cadet's ability to solve engineering problems. A 100% pass rate for three of the past four years and 93% the other year indicates PCO #1 was supported by the FE exam**.**

3.5.4 Results from the USAF Academy Graduation Survey

The results of the responses to specific questions in the USAF Academy Graduation Survey can be applied to an assessment of the electrical engineering program delivery and achievement of the Program Curricular Outcomes.

Positive scores (≥ 5.0 - Slightly Agree) indicate cadets believed the program standards and assignments are reasonable. They are also highly satisfied with academic advising and mentoring by the electrical engineering department. Cadets also are proud of their accomplishments in electrical engineering and have a high interest in learning more about the electrical engineering discipline. Their dissatisfaction with the workload in the major is not unexpected.

From 1998-2000, cadets' responses indicate they believe that too many courses were required for the electrical engineering major. Although the responses indicated they were dissatisfied with the number of courses they were required to take, it was significant that El Engr majors consistently feel better about their workload than the average of all engineering majors. Cadet workload is always of concern and a change implemented within the last few years to address this issue resulted in two fewer courses and two fewer semester hours for the electrical engineering majors. The Class of 2001 was the first class in the new curriculum and their responses were more positive (toward neutral) with a numerical score better than the mean for all majors.

Of particular interest are 2001 ratings of #1 of 20 majors for the question "I value the mentoring I received from members of my academic major" and #6 of 20 majors for "I am proud of what I accomplished in my academic major." In the narrative section, cadets listed the El Engr faculty as one of only four faculties listed by name as "the greatest strengths in the overall Academy experience."

Marginal scores from 1998 - 1999 have improved in 2000-2001 on the following question. "Academy experiences have inspired me to pursue a career of service to the nation." This is consistent with the EE Major's Exit Survey responses that cadets do not understand the role of engineering in society. The AY 2000-2001 Program Annual Assessment Report identified ways for the faculty to discuss the issue of job expectations and engineering as a profession in the classroom, at major's night, and at cadet sponsored activities. The results of the Class of 2002 surveys will be closely monitored.

Positive scores also indicate cadets believe the program enhanced their ability to frame and resolve ill-defined problems, helped them develop communication skills, and helped

them work effectively with others. Cadets also believed the electrical engineering program prepared them to become educated citizens and military officers.

3.5.5 Results from the El Engr 464 Skills Review

The El Engr 464 Skills Review results for the Classes of 2001 and 2002 are reported in Table 8.

Table 8. Results from the El Engr 464 Skills Review Supporting Program Curricular Outcomes #2, #3, and #4.

Year	Number of Cadets	High Score	Low Score	Avg Score	# Failures
2002	24	98 %	55 %	83.96 %	1
2001	11	97 %	85 %	90.18 %	0

The first El Engr 464 Skills Review was administered to the Class of 2000. It was slightly modified and administered to the Class of 2001 to baseline their performance after completing the lab sequence (El Engr 350, 351, and 352). The same exercise was administered to the Class of 2002 and also used as a measure of the adequacy of the new laboratory instructional program. Careful analysis of the Skills Review in 2002 indicates that the revised electronics curriculum has not impacted the level of hardware skills in any significant way. On average, members of this class displayed laboratory skills equivalent to that observed in the two previous classes. As with all skills review exams, the analysis provided observations and recommendations to the courses on which the exam is based when required. Note: The cadet who failed the 2002 skills review (score of 55%) did not successfully complete El Engr 464 and did not graduate with a degree in electrical engineering.

3.5.6 Results from the El Engr Major's Exit Survey

The El Engr Exit Survey asks questions to determine cadet opinions on their academic experience in the Electrical Engineering major. Nine of eleven Electrical Engineering majors responded on the El Engr 464 Exit Survey in 2001. Results were reviewed and average responses less than 4.0 (slightly agree) were addressed by the Process Improvement Principals.

Table 9 presents the results of the Exit Survey for 2001 that is given to the electrical engineering majors late in their last semester. Results of the 2002 Exit Survey will be available during the evaluation visit.

Table 9. Data for Support of the Electrical Engineering Program Curricular Outcomes by the Electrical Engineering Major's Exit Survey

Major's Exit Survey Questions \ Program Curricular Outcomes (PCOs)	1-Fundamentals	2- Lab Techniques	3 - Design/Fab/Test	4 - Contemporary Tools	5 - Communication	6 - Ethics/Profession	7 - Breadth & Depth	8 - Life Long Learning	9 - Team Members	10 - Independent Learner	11 - Engr Role in Society	12 - Contemporary Issues
1 - 2	G											
3 - 5		G										
6 - 9			G									
10 - 11				G								
12 - 13						G						
14 - 18							G					
19								G				
20								Y				
21 - 24								G				
25 - 29									G			
30 - 32										G		
33 - 34											G	
35 - 40												G
41 - 42					G							

PROBLEM: Question 20, "I am aware of current issues associated with the electrical engineering profession" scored 3.80 which is less than the desired 4.0 (Slightly Agree).

PROPOSED SOLUTION: The new CAP format addresses this for each course. CDs will encourage instructors to make sure cadets know they're discussing current events or working an example of a current issue vs. working through "yet another example."

PLANNED ASSESSMENT: Cadet feedback in the courses and next year's El Engr Major's Exit Survey results.

PROBLEM: Cadet comments showed an aversion to group work; however, they more than "slightly agree" that complex problems are better solved with groups.

PROPOSED SOLUTION: Instructors who assign group work must emphasize that group work is typically used for larger problems, not cadet harassment.

PLANNED ASSESSMENT: CD logs, cadet feedback on course critiques, next year's El Engr Major's Exit Survey results.

Integrating and analyzing the data from the five sources presented above (Course Objectives, FE Exam, USAF Academy Graduation Survey, El Engr 464 Skills Review,

and El Engr Major's Exit Survey), it is clear that the USAF Academy Electrical Engineering Program has achieved its Program Curricular Outcomes. The next section documents the changes that have been implemented as a result of assessments that suggested changes were needed to improve the electrical engineering program.

3.6 Changes Implemented to Improve Program

The Department of Electrical Engineering has had a program of continuous process improvement for many years. Prior to the increased emphasis on a documented program of assessment and continuous improvement that started in 1997, the department used a two-fold approach to ensure courses met their stated objectives. The course director compiled a Course Assessment Report after each offering of the course. Among other things this Course Assessment Report identified any deficiencies and recommended corrective action. The next course director (often the same faculty member) read the Course Assessment Report as they prepared their course. The course director of a course to be held the following semester presents the course briefing.

Course briefings are held near the end of the semester and attended by the entire department faculty. The course briefings are required to report all deficiencies from the previous offering and how they are being addressed. In addition, any change from the previous offering and the reason for it is also presented so the collective experience of the faculty can be brought to bear and newer faculty can avoid past mistakes. The following data reflecting changes made to improve the program was obtained from Course Assessment Reports and Course Briefings.

Examples of program changes implemented as a results of our assessment processes are presented in Table 10.

Table 10. Changes Implemented to Improve the USAFA Electrical Engineering Program

Change	Reason(s)	Course(s) Involved	Results
2001 - 2002			
Increase EE 463 semester hours from 1.0 to 3.0	Increase the quality of the culminating design experience. Cadet troubleshooting, planning, and documentation skills need improvement as shown in design reviews and final technical reports.	EE 463	To be Determined with Class of 2003 and subsequent Classes

Change	Reason(s)	Course(s) Involved	Results
EE 333 Require Cadets to do Programming Exercises on an 'Individual Effort' Basis	Cadets first use MATLAB in EE 332, and are allowed to get help from classmates to complete programming exercises. As a result, EE 333/434 Course Directors perceived some cadets had poor individual MATLAB programming skills.	EE 333 EE 434	EE 333 Course Director would not accept a program until it produced the required output. EE 434 Course Director will subjectively assess the result of EE 333 efforts in Fall 2002
Write full lab reports on two of the four labs in EE 281	Tried having cadets successively write a different section of a lab report for each of the four labs in EE 281, but they did not carry lessons from previous report to the next.	EE 281	Overall, writing improved from the first lab report to the second. This also provided more experience distilling data from the lab notebook into a report.
Changed lab notebook grading standard in EE 281	Poor lab notebook quality in EE 281 and EE 382	EE 281, EE 382	Better quality notebooks, but still need improvement. Enforcement of standards throughout the course is key.
2000 - 2001			
Lab Notebook Focus	Cadets forgot lab notebook requirements from sophomore year to junior year. Cadets are taught how to write the different sections, but they still prefer to make notes elsewhere.	EE 281, 382	Instructors worked together to ensure continuity. Reasons explained in EE 281 with same standards emphasized in EE 382.
Updated Processor chip	Different processor and technologies used due to changing technologies.	EE 382 EE 383	Course schedule had to be modified due to problems in the transition.
1999 - 2000			
Creation of EE 463	- Result of EE 464 assessment (cadets' inability to do common, practical tasks). - Place for engineering ethics to supplement the significant ethics background from Philosophy 310. - Place for project planning and execution skills preparation. - The "get ahead special" implemented in lieu of the last lab exercise of EE 352 demonstrated the advantages of early preparation for EE 464.	EE 464	2002 Survey of project mentors regarding quality of design projects and cadet preparation is currently under analysis. Results will be available during the evaluation visit.

Change	Reason(s)	Course(s) Involved	Results
Eliminate lab sequence and incorporate lab into electronics courses	- EE 352 course critiques showed cadets considered lab content separate from relevant classroom instruction. - Level of conceptual reinforcement of electronics required improvement	Old: EE 350, EE 351, EE 352, EE 341, EE 342 New: EE 321, EE 322	First class to complete new sequence did not have any more difficulties with their design projects.
EE 464 Skills Review	- Developed to assess laboratory skills before and after the elimination of the separate lab sequence. - Used to remind cadet of the basic hardware skills important to the design process experience.	EE 464	Analysis of results for Classes of 2001 and 2002 indicate their lab skills at least equivalent to that of previous classes.
1998 - 1999			
Lab course from full semester, single period to ½ semester, double period	Scheduling larger time blocks for labs should improve cadet efficiency. They will not require as much setup and tear down time. They will also have more time to work on the lab at a given time.	EE 350 EE 352	Cadet feedback and instructor observations were positive. Cadets had more time for labs.

3.7 Lessons Learned in Process Development and Improvement

The electrical engineering program has been process oriented since its inception; however, these processes have been formalized during the last ten years. The goal from departmental leadership to each instructor has been to ensure that new assessment activities are not added on top of the normal duties.

The process of updating old and writing new course objectives proved to be iterative. Ensuing that these objectives were measurable without significantly increasing the work load of the instructors and course directors required many faculty meetings and workshops. This process resulted in a complete review of previous assessment activities and those that did not support the course objectives were eliminated.

The development of templates greatly assisted all faculty members in preparing briefing and assessment reports. Configuration control was essential to avoid using old templates and to ensure that the essential elements of the templates required analysis and results instead of simply a presentation of data.

Consolidating the reports from courses and divisions into a program assessment report provided an excellent summary of how all the Program Operational Goals and Program Curricular Outcomes were achieved.

Several lessons learned have been documented for consideration by future key assessment personnel which include:

- Faculty must be involved from the beginning. Involving faculty in the development of goals, outcomes, and objectives gives them ownership and increases their participation in the annual assessment process.
- Writing measurable objectives is an iterative process. Course Directors were trained on the course objective writing process at an annual offsite. They were involved in an interactive activity for practice, but when it was time to write objectives for their courses, the objectives were sometimes not measurable or not clear.
- It is important to have as much assessment activity as possible be a part of an individual's standard operating procedures. All faculty expressed a concern about adding assessment activities to their current workloads. Their involvement and feedback prompted all involved to evaluate their current procedures (including course activities, planning, and additional duties) to eliminate redundant things and activities that do not support their objectives. Incorporating assessment procedures into standard procedures also helped faculty members understand their place and responsibilities in the annual assessment process.
- Templates greatly assisted the reporting process and faculty feedback helped fine tune the templates. It is important to resist the urge to constantly improve the templates. It is frustrating for the user and adds unwelcome administrative overhead to find and use the most current template.
- Standard evaluations are necessary to compare assessment results, but allowing flexibility for the faculty to determine their overall assessment (formulae, tables, etc.) is important for autonomy. It is critical to have the Course Directors specifically state whether or not course objectives were met. Otherwise, the Division Chief and Director for Assessment must analyze each course assessment report to make this determination.
- It is easy to collect and even to evaluate data, but it is equally important to use that data to initiate changes and document the results.
- Each Course Director must collect sufficient, but not excessive data for course assessment. Those who started with a "collect everything and sort it out later" approach, quickly evaluated the number of assessment methods during the report writing phase!
- Faculty and staff must be periodically briefed/updated on the results of the annual assessment process or they may be discouraged and feel their work is not being used. We must close the loop with our personnel as well in our program.

3.8 Materials Available for ABET Visitors

The following materials will be available for ABET visitors:

- Updated Tables
- Updated Faculty Vitae
- Electrical Engineering Program Annual Assessment Report for AY 2000-2001
- Electrical Engineering Program Annual Assessment Report for AY 2001-2002
- Supporting data for Program Annual Assessment Reports
- Program Curricular Outcomes Binders
  - One (1) binder per outcome
  - Summary of curricular requirements (e.g. applicable courses, assignments)
  - Samples of cadet work to support each outcome.
- Course Binders
  - One (1) binder per course
  - Course Assessment Plan
  - Course briefing for previous offering
  - Handouts for previous offering
  - Samples of cadet work for previous offering
  - Course Assessment Report for previous offering
- Assessment Plan for Electrical Engineering and Computer Engineering Programs and all linked documents
  - Program Assessment Schedule
  - Division Assessment Plans
- Electrical and Computer Engineering Advisory Board details (including minutes)
- Access to internal and external web sites
- Dean of Faculty Operating Instructions
- All Departmental Operating Instructions
- 2000-2001 USAF Academy Assessment Catalog
- 1999 Institutional Self Study
- Faculty Handbook
- Advisor Handbook
- New Faculty Orientation Materials
- ABCs of Academics (Handout for Cadets)
- 2001-2002 and 2002-2003 Catalog
- 2001-2002 and 2002-2003 Curriculum Handbook

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4. Professional Component

Students must be prepared for engineering practice through the curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating engineering standards and realistic constraints that include most of the following considerations: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political.

The professional component must include:

(a) one year of a combination of college level mathematics and basic sciences (some with experimental experience) appropriate to the discipline

(b) one and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study

(c) a general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives.

Cadets are prepared for engineering practice throughout the academic program at the U.S. Air Force Academy because the educational experience of an electrical engineering major at the Air Force Academy is a well-rounded one. All electrical engineering cadets are required to take an extensive core curriculum with courses from four different divisions: Basic Sciences, Social Sciences, Humanities, and Engineering. Courses in Military Studies and Physical Education are also required of every cadet at the Air Force Academy. This section shows how our professional component meets the curricular requirements. We also present our design curriculum and how engineering standards and realistic constraints are incorporated into our curriculum.

4.1 Curriculum

Our electrical engineering curriculum meets all ABET Criterion 4 minimum requirements in math, basic sciences, experimental experience in math and basic sciences, engineering science, engineering design, and general education. Each semester hour of credit requires 50 minutes per lesson. A typical three-semester-hour course requires meeting for one 50-minute period every other day and 100 minutes per lesson of outside work for 42 lessons every semester. For comparison purposes in the following sections, sixteen semester hours equal one-half year of study. One academic year contains 34 weeks of instruction exclusive of final examinations.

4.1.1 Math and Basic Sciences

Cadets in the electrical engineering program complete a total of 39.0 semester hours in math and basic sciences (1.22 years of study). Breadth is achieved by required courses in calculus, probability and statistics, physics, chemistry, and biology. These courses in the core program have been carefully chosen by the Academy to give all cadets a broad education and the tools to be complete military officers. Depth in mathematics is achieved by requiring a total of three calculus courses, one in differential equations. Experimental experience is developed in four of the required science courses; two in physics and two in chemistry. A listing of these courses is provided at Tab A in Table I-1 and course descriptions may be found in the USAFA 2002-2203 Curriculum Handbook. The Curriculum Handbook is the Academy's official curriculum document and contains the most recent information available.

4.1.2 Engineering Topics

Cadets in the electrical engineering program complete a total of 57.5 semester hours in engineering topics (1.80 years of study) as shown in Table 11. Breadth is achieved by required core courses in engineering mechanics, civil engineering, aeronautical engineering, and astronautical engineering. The core program also includes a project-based engineering course taken in the senior year. As a result of a recent Academy-wide assessment and resulting curriculum changes during the past year, this project-based course will be moved to the freshman year to allow cadets an earlier view of each engineering discipline. These courses in the core program have also been carefully chosen by the Academy to give all cadets a broad education and the tools to be complete military officers. Depth in engineering is achieved by the electrical engineering curriculum.

Table 11. Program Credit Hours in Engineering Topics

	Semester Hours		
	Engineering Science	**Engineering Design**	**Total**
Required El Engr Courses	24.75	12.25	37.00
Minimum Science for 2 Electives	1.70		
Minimum Design for 2 Electives		1.00	
Minimum Sem Hrs for 2 Electives			6.00
Required Engineering Core Courses			14.50
Total semester credit hours	27.45	13.25	57.50
Minimum semester credit hours			48.00

A listing of these courses is provided in Table I-1 and course descriptions are provided in Appendix I-B as well as the USAFA 2001-2002 Curriculum Handbook.

4.1.3 General Education

Cadets in the electrical engineering program complete a total of 45.0 semester hours in the humanities and social sciences (1.40 years of study). Breadth is achieved by required core courses in English, foreign language, history, and philosophy in the humanities and behavioral science, economics, law, management, and political science in the social sciences. These courses in the core program have also been carefully chosen by the Academy to give all cadets a broad education and the tools to be complete military officers. Depth in humanities and social sciences is achieved by requiring three courses in English, two in a foreign language, and two in political science.

4.2 Design Experience

The philosophy of the electrical engineering program is to infuse the entire curriculum with opportunities to practice the design process. Many of the required electrical engineering courses have a significant percentage of engineering design. Most have a laboratory component designed to illustrate the principles and give the cadet practice applying the theory they have learned. The curriculum culminates in a two-course major design experience.

Cadets are introduced to engineering design in the sophomore year. As they learn basic analog and digital circuit design in El Engr 231, Electrical Circuits and Systems I, and El Engr 281, Introductory Digital Systems, they are required to design simple circuits to meet specifications. Examples include operational amplifier circuits, first-order filters, and sequential state machines. Cadets who choose to take Engr 311, Electrical Power Systems, in the sophomore year are introduced to power system design as well as AC and DC motor design assignments.

During the junior year, cadets are presented experiences in four areas of emphasis in the electrical engineering curriculum: electronics, signals and systems, computer systems, and communications. In El Engr 321, Electronics I, cadets receive formal instruction in the design process which is reinforced through two laboratory exercises on bipolar and MOS transistor amplifiers. In El Engr 322, Electronics II, cadets expand this design experience through laboratories on differential pair amplifiers, linear amplifiers with feedback, and CMOS digital circuits. Both parametric and block circuit design are emphasized. Our cadet's basic competence in the design of electronic circuits is assessed in this course. Analog circuit design is continued in El Engr 332, Electric Circuits and Systems II, where cadets design resonant circuits and higher-order filters. El Engr 382, Microcomputer Programming, includes lab exercises in which cadets design software and circuits to study various aspects of the Motorola 68HC12 microcontroller (interrupts, timing, I/O ports, etc.) that culminates in the development of a tethered robot navigating a maze. Finally, design exercises are included in the required electromagnetics course, El Engr 443, in homework and for exams.

In the fall of the senior year, El Engr 463, Design Project Techniques, leads the cadet through a design process. In this course, each cadet chooses a major design project and a faculty mentor. Preliminary design work such as requirements definition and high-level block diagram design is accomplished during El Engr 463. The follow-on course, El Engr 464, Design Project, is taken in the spring of the senior year. The project is completed during this course. Throughout El Engr 464, cadets are prepared for engineering practice in two main ways. They have the responsibility for the design, fabrication, and testing of a major project. They also are required to practice technical communication skills in the form of formal briefings at three key points in the project. They are required to write a comprehensive technical report, with a draft of the report turned in after each major briefing.

Juniors and seniors also take elective courses to facilitate in-depth study in an area of concentration, such as communications, computer engineering, or Very Large Scale

Integrated (VLSI) circuit design. These additional courses, as evidenced in Table 12, provide significant opportunities for more design experience.

Table 12. Engineering Design in Elective Courses

	Semester Hours	
	Engineering Science	**Engineering Design**
El Engr 383 - Microcomputer System Design I	1.5	1.5
El Engr 387 - Introduction to Robotic Systems	2.0	1.0
El Engr 444 - Applied Field Theory	1.5	1.5
El Engr 448 - Communications Systems II	2.0	1.0
El Engr 485 - Computer Architecture	3.0	0
El Engr 495 - Special Topics (Amplifier Design)	1.2	1.8
El Engr 499 - Independent Study	TBD	TBD

Courses involving labs are carefully sectioned to insure each cadet has appropriate access to all equipment. As such, laboratory exercises and design projects are almost always completed on an individual basis or by a team of two. On occasion, when a complex project can be suitably partitioned, a larger design team may be approved. This approach of laboratory and design work throughout the program, with a year-long design experience at the end of the program, gives the cadets practice in the design aspects of engineering.

All members of the electrical engineering faculty serve as mentors for the El Engr 463/464 design project course sequence. Approximately half of the Fall semester is devoted to design project selection, planning, high-level design, and advanced procurement of parts. Instructors provide project proposals early in the semester and give short presentations to the cadets in El Engr 463, Design Project Techniques. Cadets have the opportunity to discuss the projects with the potential mentors and must choose a project by the middle of the Fall semester. A Systems Requirements Review and Initial Design Review are held during the second half of the semester to give the cadets the opportunity to start the detailed design of the project immediately after the holiday break.

During the first three weeks of the spring semester, cadets are required to hold a Preliminary Design Review and draft an outline of the final technical report. They must hold a Critical Design Review wherein they present a completed design and have a working prototype demonstrated before mid-term.

Example projects for the last few years include a walking robot, audio mixer, Digital Signal Processing-based software radio, electronic metal detector, at least 18 high performance audio amplifiers, FalconSat2 power system, bullet speed measuring device, noise-canceling

headphones, ultra-wideband antenna, prosthetic arm, 68HC11 Derby Timer, and two BattleBots which were featured in *Newsweek* (May 28, 2001), the Air Force news site (http://www.af.mil/news/May2001/n20010522_0693.shtml), and various Air Force publications. Both BattleBots also participated in the Comedy Central network competition. Unfortunately, neither advanced to a televised round, but they did participate in a special exhibition robot rumble that was arranged by and televised on NBC's "The Tonight Show." As a result of the media exposure, the cadets were invited to technology fairs in nearby towns to demonstrate engineering applications. Several undeclared cadets have expressed interest in an electrical engineering degree after seeing the BattleBots at open houses and hearing the audio amplifiers designed and built by fellow cadets.

Almost all required and elective courses in the electrical engineering program provide some design experience for cadets. As theory is presented in the class, cadets apply this basic knowledge to homework problems, laboratories, and computer exercises at both the analysis and synthesis levels. A main objective of the design experience is to improve the ability of our cadets to frame and resolve ill-defined problems. As cadets progress through the program, the problems to be solved are progressively less well-defined. Then in the capstone senior design course, cadets integrate knowledge and skill from all courses as they frame and resolve very open-ended design problems.

4.3 Engineering Standards and Realistic Constraints

In the electrical engineering program, the assessment process requires that the Course Assessment Plan for each course document coverage of the professional component: economic, environmental, sustainability, manufacturability, ethical, health & safety, social, and political considerations. Any given course may cover some, all, or none of these considerations, but as part of the Course Assessment Plan review process, the Process Improvement Principals ensure a thorough coverage throughout the curriculum.

During the course briefings, held before the start of each semester, the Course Directors describe in detail how they plan to implement the Criterion 4 considerations outlined in their Course Assessment Plan. All department faculty are required to attend these briefings so all instructors can be assured all Criterion 4 topics are planned to be covered and to what degree in each course. At the end of each semester, Course Directors document in their Course Assessment Reports how their course actually did cover each Criterion 4 topic. A summary is then included in the Program Annual Assessment Report, thus ensuring that the planned coverage actually occurred.

The Electrical Engineering Department discusses the topics required by Criterion 4 throughout the electrical engineering curriculum. In the required electromagnetics and communications courses, Criterion 4 issues are discussed as they relate to electromagnetic radiation and communication methods. In the electronics courses, Criterion 4 issues are discussed related to chip manufacturing and impact on society. In the digital courses, Criterion 4 issues are discussed as related to choice of logic families, and impact of computer technology such as microprocessors and robots on our world. Many of these issues are combined in El Engr 463/464, the capstone design course.

Engineering ethics are covered informally in several courses (as outlined in the Course Assessment Plans) and to help the cadets understand ethical issues specific to engineering, engineering ethics are discussed in El Engr 463 as part of a case study. At key points in the design process of their capstone design experience (El Engr 463 and 464) cadets are required to formerly address all of the issues in Criterion 4 as related to their project. This is accomplished via briefings and technical reports.

In addition, all cadets are required to take a course in ethics as part of the general core curriculum. Philosophy 310, Ethics, taught by the Department of Philosophy provides a study of major moral theories and their application to contemporary moral problems with special emphasis on the moral problems of the profession of arms. Since "Integrity First" is one of the core values of the U.S. Air Force, the officer candidates at this institution are required to practice the ethical lessons taught in class on a daily basis. They have the opportunity not only in the academic environment, but also in the athletic and military training environments to demonstrate their integrity.

4.4 Preparation for Engineering Practice

Through the USAF Academy's carefully planned curriculum, cadets gain breadth of knowledge in the humanities, social sciences, basic sciences, and engineering as well as breadth and depth in the field of electrical engineering. They use their knowledge in a wide variety of problem solving exercises and experiences starting with well defined problems and advancing to less defined problems throughout the core and electrical engineering program. The problem solving process is introduced in theoretical courses and emphasized in the design component of the curriculum.

4.4.1 Honor, Ethics, and Professionalism

As outlined above, the concepts of ethics and professionalism are inseparable as developed within the cadets and reinforced through all activities offered at the Academy. High standards of ethics, honor, and professionalism are required of each cadet by their Honor Code and are enforced by cadets with officer guidance as required.

The Honor Code by which the cadets live is an ideal embodied in the meaning of military professionalism. Their formal training in the Honor Code includes more than 37 hours of briefings and lessons during their four years at the Academy. This includes education and training in their initial "Basic Cadet Training" the summer before their freshmen year, annual training during each academic year, and an informal seminar in their senior year (Academy Character Enrichment Seminar (ACES)) for the discussion of character issues and dilemmas facing junior offices.

The cadet Honor Code principles: "We will not lie, steal, or cheat nor tolerate among us anyone who does" are behavioral standards nurtured throughout a cadet's development. All new faculty members are introduced to the Honor Code and Honor System during their week long orientation and all faculty are required to have annual honor training. In

the Department of Electrical Engineering, this training is enhanced with annual honor training at the back-to-school offsite before the Fall semester begins.

4.4.2 Process Management

Social and economic considerations of engineering practice are studied in our extensive core social sciences curriculum. Management 210, Introduction to Management, covers many aspects of engineering economy. This course surveys engineering economics topics such as alternative decision making, economic decision making, opportunity costs, alternative manufacturing decisions, process costing, economic life, and management information systems.

In Engineering 410, Engineering Systems Design, cadets gain practical experience in both social and economic implications of engineering. Each class forms a company to write a proposal for an Air Force contract. The semester is spent in analysis, design, fabrication, and testing of the product. During the process, trade-offs between cost, performance, and time must be continuously made as each section is limited in the amount of money and resources that are available. Social and government restrictions play a large role in the projects because they usually affect either Air Force or local community affairs. Instructors from all engineering departments teach the course.

As a result of an Academy wide assessment, Engineering 410 will be replaced with a first year course which will introduce cadets to all the engineering disciplines. Project management and the design process experience will not be lost because the new required course in the electrical engineering program El Engr 463, Design Project Techniques, will increase from a single semester hour course to a three-hour course. This change provides more time for studying and applying project management and the design process as well as an ethics case study, requirements refinement, initial design, and a design review. This will also provide the cadets more time to iterate their designs in El Engr 464, Design Project, which should improve their skills as well as their products.

El Engr 464 is required of all electrical engineering majors in their final semester. The projects are specifically selected to draw on the cadet's previous electrical engineering course work. Understanding cost, performance, and schedule trade-offs as well as engineering constraints are an important part of the course objectives. All electrical engineering faculty members serve as mentors for the cadet engineers.

4.4.3 Oral and Written Communication

The Department of English is primarily responsible for developing and ensuring competence in oral and written communication at the Air Force Academy. All departments, however, are urged to help develop the writing and speaking skills of their cadets by insisting on correct English in all written and spoken assignments, encouraging oral recitation where appropriate, and assigning a portion of the grade on every assignment to the use of proper English. In this way, all departments contribute to the Academy's Writing Across the Curriculum program. Departments in the Engineering

Division require at least 10% of the total grade on writing assignments be allotted to writing mechanics and overall ability to communicate. Deductions for written communication are clearly indicated to encourage cadets to improve writing skills.

All graduates are required to take and pass two courses in written and oral communication:

English 111 - Language and Expression I. Emphasizes the fundamental uses of language, concentrating on sound academic writing and the rhetoric of argument. Establishes the foundation for analytical thinking through frequent writing assignments, including a research paper, that derive from and reinforce a wide range of readings ranging from scientific and historical articles to modern poems and short stories.

English 211 - Masterpieces of Literature. Refines analytical and critical reading skills introduced in English 111 through the rhetorical examination of significant literary texts written by some of the world's great writers. Concentrates on masterpieces and contemporary works that reflect our culture and values, particularly those that focus on moral and ethical issues and examine relevant concerns such as leadership, heroism, integrity, and the individual and social responsibility. Written assignments and oral presentations emphasize persuasive argument and research.

The primary institutional standard for communication skills is the successful completion of the two English courses, which are part of the graduation requirements.

Electrical engineering majors must demonstrate communication skills in all electrical engineering courses. Most courses require reports on laboratory projects and/or computer exercises. Grade reductions result from incorrect grammar, misspelling, poor sentence construction, and inability to convey concepts. Unacceptable work is returned for correction and resubmission. In addition, each cadet is expected to actively participate in the lecture/recitation periods and many courses require oral presentations.

In addition to these requirements, all cadets are called upon to make written and oral presentations in their professional military studies programs monitored by the Commandant of Cadets. Further, the Academy's Writing Across the Curriculum program monitors the amount and type of written work required in courses offered by each department. With this information, the Academy ensures that cadets develop their writing skills throughout the curriculum.

4.4.4 Cadet Summer Research Program

The Cadet Summer Research Program (CSRP) is designed to increase cadets' skills in their field of study by applying the knowledge they have gained through academic study to solve actual research problems. By working side by side with military, government, and civilian researchers, cadets learn problem solving and information gathering skills which will help them to become more effective engineers. Each year over 100 cadets

participate in this program which extends to over 70 locations worldwide. Approximately 25% of the electrical engineering majors are sent to one of 20 locations. This five week temporary duty assignment also gives the cadets a glimpse of the operational Air Force and allows them to see the workings of a "real-life" engineering unit and Air Force base. For those cadets who get the opportunity to participate, the Cadet Summer Research Program becomes a vital part of their academic and military educational experience.

The Cadet Summer Research Program is extremely competitive with high academic and military standards. The Electrical Engineering Department sends about 25% of its cadets each Summer. In previous years, cadets have worked at the following locations:

- Central Intelligence Agency, Power Sources Center
- Directed Energy Directorate, Air Force Research Laboratory, Kirtland AFB, NM
- 85th Test and Evaluation Squadron, Detachment 1, Tyndall AFB, FL
- Combat Air Forces Command and Control Systems Program Office, Electronic Systems Center, Hanscom AFB, MA
- Engineering Microtechnology Division, Lawrence Livermore National Laboratory, Livermore, CA
- Air Force Research Laboratory Sensors Directorate, Wright-Patterson AFB, OH
- Neutrino Science Center, Los Alamos National Laboratory, Los Alamos, NM

Cadets write reports upon their return and brief the entire Department of Electrical Engineering on their research work which has included topics such as:

- Thermal Protection of Weather Balloon Batteries Experiment
- Radar Test Range Instrumentation
- Power Requirements for Data Collection and Exfiltration System
- Radio Frequency Particle Acceleration
- Theater Battle Management Core System
- Design and Fabrication of a Polymer-Based Electrostatic Microactuator
- Set-up and Use of Two LADAR Imaging Cameras

In the summer of 2002, we expect to send six cadets to six locations:

- Central Intelligence Agency
- Georgetown Program, Prague, Austria
- Air Force Research Lab Sensors Directorate, Hanscom AFB, MA
- 28th Test Squadron, Tyndall AFB, FL
- Global Positioning System Joint Program Office, Los Angeles AFB, CA
- Arnold Engineering Development Center, Arnold AFB, TN

4.4.5 Student Chapter of the Institute of Electrical and Electronics Engineers (IEEE)

The department sponsors a student chapter of the Institute of Electrical and Electronics Engineers (IEEE). The student chapter sponsored a faculty-wide presentation by General (ret) Donald Kutyna, the country's lead investigator into the space shuttle Challenger accident, on "Engineering Ethics in Connection with Space Shuttle Challenger Disaster."

The chapter was host to almost 200 students from more than 20 universities at the 2001 IEEE Region 5 Student Professional Activities Conference (S-PAC) and Student Design Contest. A total of 10 cadets participated in this conference. Field trips are taken each year to Air Force laboratories and local companies such as Dunlavy Audio Laboratories and United Technologies.

4.4.6 Student Chapter of Tau Beta Pi

To encourage engineering excellence and recognize the cadets who achieve it, the USAF Academy established a chapter of Tau Beta Pi, the national engineering honor society on March 8, 1997. Prior to the installation of Colorado Zeta, the USAF Academy Tau Beta Pi Chapter, the Engineering Division sponsored the USAF Academy Engineering Honor Society to serve as the precursor for the Tau Beta Pi Chapter.

4.4.7 Cadet Amateur Radio Club

The Cadet Amateur Radio Club is an interdisciplinary group with cadets majoring in electrical engineering, materials sciences, physics, computer science, chemistry, meteorology, and aeronautical engineering. The club has communications capabilities in the HF, VHF, and UHF frequencies with HF contacts routinely made as far away as Europe, South America, the South Pacific, and even one in Russia. The VHF/UHF equipment is configured for satellite as well as terrestrial communication.

The Cadet Amateur Radio Club is supported by a combination of cadet dues and solicited grants from agencies such as the Association of Graduates (AOG). Since the Officer in Charge (faculty advisor) is a member of the electrical engineering faculty, the electrical engineering program often benefits from the club's activities and acquisitions. An example is the use of hand-held transceivers for direction-finding exercises to test direction-finding antennas in El Engr 443/444. Also the club's radio equipment has been used to demonstrate modulation techniques in El Engr 447, Communications. The club is available for demonstrations to all El Engr classes. For the past three years, the club Cadet in Charge (CIC) has been an electrical engineering major (a different senior each year). The CIC just elected for next year is also an electrical engineering major.

4.4.8 Fundamentals of Engineering Exam

Seniors majoring in ABET-accredited engineering programs are encouraged, but not required to take the Fundamentals of Engineering (FE) exam. In the spring of 1996, an engineering division assessment committee surveyed cadets from all accredited majors to discover what would better motivate them to take the FE exam. Results showed that faculty encouragement, the Engr 402 course, Professional Engineering Development, and funding were key issues.

Electrical engineering advisors encourage cadets to enroll in Engineering 402. This course is designed to prepare cadets for the Fundamentals of Engineering examination and is managed by the Department of Civil Engineering. The course is multidisciplinary in approach and includes: engineering mechanics, mechanics of materials, electrical

circuits, mathematics, fluid mechanics, thermodynamics, computer programming, chemistry, and engineering economics. Engr 402 is taught by instructors from across the Engineering Division.

Senior faculty members discuss the purpose and importance of the FE exam with cadets at the back-to-school meeting before their senior year. Faculty are reminded to discuss it during the school year, but especially at the beginning of the spring semester that the special offering of the exam is administered at the Academy. This is typically a good time for other instructors to introduce the concept of engineering licensure to the sophomore and junior electrical engineering majors, since they often hear the seniors discussing it.

Assessment funds are made available to cover the exam costs for majors in accredited engineering programs who choose to take the exam during the special offering at the Academy each spring. Results are reviewed annually and incorporated into the Program Annual Assessment Report.

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5. Faculty

> *The faculty is the heart of any educational program. The faculty must be of sufficient number; and must have the competencies to cover all of the curricular areas of the program. There must be sufficient faculty to accommodate adequate levels of student-faculty interaction, student advising and counseling, university service activities, professional development, and interactions with industrial and professional practitioners, as well as employers of students. The faculty must have sufficient qualifications and must ensure the proper guidance of the program and its evaluation and development. The overall competence of the faculty may be judged by such factors as education, diversity of backgrounds, engineering experience, teaching experience, ability to communicate, enthusiasm for developing more effective programs, level of scholarship, participation in professional societies, and registration as Professional Engineers.*

The Electrical Engineering Department faculty is composed of one Permanent Professor (Department Head), one Senior Military Professor, two professors, five associate professors, three assistant professors, three instructors, four laboratory technicians, and one secretary. All of the faculty are full-time employees, and they perform administrative duties in addition to teaching. Of the seventeen faculty members, three are long-term civilian members. In addition, each year one or two visiting professors are also members of the faculty. These visiting professors are typically from other academic institutions, and are well know in their respective discipline. All have earned doctoral degrees.

The faculty is made up of professional military officers and hand picked civilian professors with graduate degrees in electrical engineering (currently 82% of the department faculty hold Ph.D. degrees, and the remaining hold MSEE degrees). These individuals bring backgrounds and interests in a wide variety of curricular areas to the program (see the faculty vitae in Appendix I-C for more information on backgrounds and interests). There are sufficient faculty to implement our electrical engineering curriculum. In rare cases of unexpected personnel changes, the senior leadership of the faculty have provided funds for temporary civilian instructors.

5.1 Adequacy of Faculty

The faculty of the Electrical Engineering Department numbers between 17 and 22. We currently have 17 members. On average, the department instructs 700 cadets per semester, 85% of which are core students, i.e., non-electrical engineering majors. Faculty members teach between two and four sections and class sizes are limited to 24 cadets. This results in a maximum ratio of 24 cadets per faculty member during lectures and laboratories. For laboratory intensive courses, the maximum number of cadets is between 8 and 15, thus lowering the cadet-faculty ratio to allow more interaction and technical assistance. This small ratio is a cornerstone of the USAF Academy philosophy of giving as much individual attention to each cadet as possible. In conjunction with the significant office hours available to cadets for advising and help outside the classroom, cadets enjoy easy accessibility to instructors.

In addition to instruction, each faculty member advises six to seven electrical engineering cadets, and three to four computer and/or general engineering cadets. This small ratio allows excellent interaction between individual faculty and cadets. In addition to advising engineering majors, an average of three faculty members also act as academic advisors to

first year (freshmen) cadets not yet declared. Typically, each of these advisors handles about 30 cadets. However, most of the first three semesters are core courses required of all Academy cadets. Their schedules are set by the registrar as they enter the Academy, so there is little time actually spent advising each of these cadets.

Due to the small enrollment of individual classes (24 cadets maximum, less in laboratory intensive courses), faculty-cadet interaction is maximized. In addition, all faculty members can interact, counsel, or assist cadets anytime they are not teaching. These "office hours" average approximately 22.5 hours per week, per instructor. For additional support of all laboratory courses, the department also has four full-time electronics technicians who assist the instructor during any class period that involves laboratory experiments. This significantly enhances the laboratory experience for cadets since they can almost always receive immediate feedback on questions that may arise during the laboratory exercise.

As discussed earlier, the electrical engineering faculty is composed of 17 full-time members with 82% holding Ph.D. degrees and the remaining holding MSEE degrees. These individuals bring backgrounds and interests in a wide variety of curricular areas to the program, including analog and digital circuits, electronics, linear systems, microprocessors, electromagnetics, analog and digital communications, radar, instrumentation, computer architecture, signal processing, and optoelectronics (see the faculty vitae in Appendix I-C for more information on backgrounds and interests). The electrical engineering curriculum is divided into four areas: signals and systems, electronic systems, communications, and computer systems. As faculty members leave for other assignments, our departmental personnel system chooses potential candidates to ensure there are no vacancies in any of these areas.

Faculty members also serve on a number of Engineering Division, Faculty- and Academy-wide committees and advisory boards. These cover a number of different topics and faculty are usually given the opportunity to volunteer for these committees and boards. Typically, these do not require extensive amounts of time, and are generally supported during times when cadets are not available (lunch, military training, summer, etc.)

5.2 Engineering and Teaching Experience

Assignment to the Academy is voluntary and highly competitive, and only officers with outstanding military and academic records are selected to serve on the faculty. On the civilian faculty side, assistant professors are selected and interviewed from a large pool of applicants. The typical military faculty member serves for three to four years, while civilian faculty serve on renewable multi-year contracts (for more detail on the Civilian Faculty Program, see Appendix II, Section B.6).

The majority of the electrical engineering faculty has at least six years engineering experience at the time of assignment to the Academy. Most are engineers with other than academic experience (research and development, industrial, test and evaluation, etc.). Thus the department benefits from a constant influx of experienced engineers knowledgeable in the state-of-the-art and familiar with real engineering problems. Each year, one or two junior

faculty members are selected to pursue doctoral degrees at top institutions around the country. These officers return to provide expertise and leadership to the department for at least another four years. Currently nine of the most senior leadership positions are held by such returning faculty members.

As can be seen in Appendix I-C, Faculty Vitae, the Department of Electrical Engineering currently has three faculty members with less than five years of teaching experience. There are nine faculty with five to ten years of experience, and five faculty have more than ten years teaching experience.

5.3 Professional Development

Each year, new faculty members participate in a comprehensive summer training program, called Faculty Orientation, during which they learn about the Academy mission, operations, cadet life, and a variety of effective teaching and learning styles. New faculty also assist in department-run summer academic sessions by preparing and delivering lectures, developing and grading exams, and attending educational seminars. A large part of Faculty Orientation is administered by the Faculty Development Division of the Academy's Center for Educational Excellence (DFE), with remaining program-specific activities run by the electrical engineering department.

During the academic year, classroom teaching performance is monitored by senior faculty members as well as by peer-auditing. Constructive feedback is provided to help insure a high quality of education. Educational seminars, provided by DFE as well as in the department, address such issues as test design, grading, educational technology, etc. and occur throughout the year. Attendance at many of these seminars is mandatory for first-year faculty. The result of these efforts is a very cohesive, motivated, and professional faculty dedicated to undergraduate engineering education. During each semester, the faculty attends a number of departmental seminars presented by one of the faculty members. These seminars typically involve presentations on current research projects or other items of interest.

The teaching loads leave time for research and faculty professional development, as appropriate for the teaching-oriented mission of the Academy. Some examples of recent professional development efforts include innovation in classroom and laboratory techniques, participation in course directors' workshops, participation and attendance at local and national American Society for Engineering Education (ASEE) annual conferences, local Institute for Electrical and Electronics Engineers (IEEE) section meetings, and engineering projects (consulting) for other Air Force agencies. A sabbatical program is in place for civilian instructors and sequential tour officers (serving extended military assignments beyond the typical four years). In addition, civilian instructor contracts are reviewed and are typically renewed every three years. USAFA Regulation 36-3, available with the course materials at the time of visit, contains details for these programs.

Two of our full time faculty and one of our visiting civilian professors have been licensed professional engineers for many years. In addition, during the past six years, seven faculty

members have successfully taken the Professional Engineering exam and all of these are now licensed as professional engineers.

5.4 Participation in Professional Societies

Faculty members are active in a variety of professional organizations, including the Institute of Electrical and Electronics Engineers (IEEE), the American Society for Engineering Education (ASEE), the Armed Forces Communications and Electronics Association (AFCEA), the International Society for Optical Engineering (SPIE), and the Rocky Mountain Biomedical Society (RMBS). In the past six years, department members have served as IEEE officers (vice-chair and chair of the Pikes Peak Area), served on the RMBS board of directors, served on the IEEE national licensure committee for professional engineer certification, visited other campuses as ABET evaluators, authored papers in a variety of professional publications, and served as session chairs at technical and educational conferences and symposia.

Every department faculty member is highly encouraged to attend at least one professional conference or activity per year (IEEE, ASEE, short course, etc.) to help stay abreast of technological and educational advancements. Our Division Assessment Reports report on both faculty development and participation in professional societies.

5.5 Guidance, Evaluation, and Development of the Program

The entire faculty takes an active approach in the continued development and improvement of the electrical engineering program at the Academy. Each member participates in the review of courses in their areas of specially. Course content and administration is reviewed by the entire department during formal course briefings at the end of the semester before they are offered. The course briefings are presented by the course director (lead instructor for the course) and cover such areas as syllabus, grading criteria, textbook, lesson schedule by topic, lessons learned from previous offerings, and any other information pertinent to the course.

In addition to the formal course presentations, reports on individual courses are done at the end of the semester and include, as a minimum, all of the material presented during the course briefing, final grades, assessment information (tied to specific course objectives outlined in the syllabus and the Course Assessment Plan), and any lessons learned during the semester. Faculty members also observe each other's instruction techniques and style during formal class observation sessions. Each instructor is expected to observe at least two other instructors during each semester. These sessions are formally tracked on a bulletin board tracking system, ensuring 100% member participation.

The department also has a standing curriculum committee that reviews all proposed changes to individual courses, the electrical engineering program at-large, and any other impact to the approved program. Their purpose is to control changes to the curriculum through a formal review and approval process. This committee also works with an Academy-wide curriculum committee to determine how other non-electrical engineering courses may affect our courses (prerequisites, course content, etc.). Finally, the Advisor-in-Charge for the electrical

engineering program is also the department's liaison to the math department, ensuring any proposed changes to math programs are well understood by the electrical engineering department and curriculum committee for potential impact to prerequisite materials for electrical engineering courses. This person also serves as the focal point for the Department of Electrical Engineering's feedback to the math department regarding electrical engineering major's mathematical preparation.

The department hosts a full day "offsite" just before the beginning of the fall semester. This meeting is used to review and update the faculty on department administration, changes to curriculum and academics, the assessment process, and professional development. It also serves as an opportunity to build enthusiasm among faculty for the upcoming school year.

The department formed a team of Process Improvement Principals (PIPs) to evaluate all assessment activities of the electrical engineering (and computer engineering) programs on a regular basis. This group typically meets twice each month, and discusses such items as quality of instruction, program assessment, instructor professional development, and course development. This group's membership is diverse – it includes those with significant teaching experience (8^{+} years), instructors recently returning from operational Air Force assignments, licensed professional engineers, senior department personnel as well as members of the computer science department (for the computer engineering program). The outcomes of the group's discussion often include recommended changes to course content, assessment activities, etc. The Process Improvement Principals serve as the Configuration Control Board for all assessment documents associated with the Assessment Plan for Electrical Engineering and Computer Engineering Programs as well as the plan itself. This ensures the department assessment activities remain integrated and adequate to do the job.

The Department of Electrical Engineering faculty has the qualifications, motivation, and leadership support and encouragement to evaluate and improve the electrical engineering program. The program annual assessment process uses inputs from all faculty and support personnel to ensure the program is adequate and that program and supporting goals and objectives are met.

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6. Facilities

> *Classrooms, laboratories, and associated equipment must be adequate to accomplish the program objectives and provide an atmosphere conducive to learning. Appropriate facilities must be available to foster faculty-student interaction and to create a climate that encourages professional development and professional activities. Programs must provide opportunities for students to learn the use of modern engineering tools. Computing and information infrastructures must be in place to support the scholarly activities of the students and faculty and the educational objectives of the institution.*

Our facilities, which include classrooms and laboratories and the equipment residing therein, are sufficient to meet our department course needs and objectives. We have dedicated classrooms, dedicated laboratories, and combined classroom/laboratories. Furnished with state-of-the-art equipment, supplies, computers and software, the cadets have all the necessary resources to meet the requirements of the various courses as well as any independent study or research they may wish to undertake.

6.1 Adequacy of Facilities

Individual attention to each cadet is one of the strengths of the USAF Academy educational program in general and the electrical engineering program in particular. The maximum allowable section size for any electrical engineering course is 24 cadets. Many courses have lower maximums, and most upper division electrical engineering sections, including those that emphasize design, have 10-20 cadets. Although teaching styles vary, maximum cadet participation in the learning process is emphasized in all electrical engineering courses through the use of board work, worksheets, quizzes, etc., providing instructors an opportunity to interact with cadets one-on-one during the learning process. This is greatly assisted by the facilities. Our faculty offices were designed to be adjacent to our classrooms and laboratory spaces to assist cadet-faculty interaction.

We intentionally keep the cadet-to-instructor ratio small in the laboratory courses (El Engr 321, El Engr 322, El Engr 382, El Engr 383, El Engr 444, El Engr 447, El Engr 495) so that this interaction can be effective. When enrollment increases, we add additional sections to avoid large section sizes. The maximum section size is determined by laboratory space, equipment inventory, and desired cadet-to-instructor ratio based on the course syllabus.

A summary of facilities is outlined in Table 13. It details the condition, use, and size of all classrooms, dedicated laboratories, and combination classroom/laboratory rooms.

- Integrated classroom and laboratory rooms are used for all introductory courses (El Engr 231, El Engr 281, Engr 311). Dedicated laboratory equipment at each station is available for use during lecture, integrated class exercises of lecture and laboratory, and for laboratory experiments. Combination classroom/laboratories are used for the computer systems courses as well (El Engr 382, El Engr 383, and El Engr 484).
- Classrooms for the communications, electromagnetics, and electrical power courses have equipment stored in the classroom, but it is only set up for demonstrations, laboratories, and integrated class exercises.
- Dedicated laboratories are used for research and courses in robotics, optics, signal processing, design techniques (El Engr 463), and projects (El Engr 464), VLSI

fabrication, instrumentation, and electronics. The anechoic chamber is available for the electromagnetics courses and research.

The only area of concern is the lab space for El Engr 464 (Design Project). If we increase our electrical engineering majors enrollment number, we will have a need for more dedicated El Engr 464 bench space. Currently, El Engr 464 and El Engr 495 cadets occupy several of the laboratory stations within 2G24 (electronics) and 2E48A (computer systems) for their senior design projects, which has not yet conflicted with other on-going laboratory course space requirements. In response to this potential problem, new laboratory areas are being installed in 2F2 and 2-6D. A redistribution or reconfiguration of our current laboratory space may still be required to relieve the strain on course needs by the requirement for dedicated senior project space. This will be addressed during AY 2002-2003.

6.2 Adequacy of Equipment

Our classrooms and laboratories have a wide range of electronic equipment, supplies, and computer software available for cadet use throughout their coursework. A list of current equipment used is included as Appendix I-E. Courses involving labs are carefully sectioned to insure each cadet has appropriate access to all equipment. Laboratory exercises and design projects are almost always completed on an individual basis or by a team of two. On occasion, when a complex project can be suitably partitioned, a larger lab team may be approved.

The department is divided into four divisions, each responsible for approximately one-fourth of the courses offered. The department's resource manager is responsible for coordinating the planning for new purchases and replacing obsolete equipment by consolidating inputs from across the department. A standard Air Force seven-year budget projection is used, updated continuously, and reviewed by the senior staff at least annually. This plan forms the basis for the department's input to the USAF Academy's current budget as well as the next year's Financial Plan and Program Objective Memorandum (following six years).

Equipment is maintained by four department technicians and the USAF Academy Precision Measurement Equipment Laboratory (PMEL), located in the same building as the department. The PMEL calibrates all measurement equipment on a schedule determined by the type of equipment. One department technician is typically responsible for the maintenance of the equipment in a particular division. The fourth technician is responsible for equipment supporting our core courses. Our technicians are:

- Electronic Systems Division:
  Mr. Richard Speakman (38 years experience, 14.5 years at USAFA)
- Computer Systems Division:
  Mr. Jon Trudeau (18 years experience, 14 years at USAFA)
- Communications Division:
  Mr. William Doyle (35 years experience, 4 years at USAFA)
- Core Technician:
  Ms. Susan Elmore (22 years experience, 9 years at USAFA)

Table 13. Classroom and Laboratory Facilities

Room No.	Purpose of Lab & Classroom, Courses Taught	Condition of Lab	Adequacy for Instruction	Cadet Stations	Area (Sq Ft)
2-4A	Robotics Lab: EE 387, EE 464, Research	Excellent	Adequate	On demand	392
2D26	Image Processing, Optics, Digital Signal Processing: EE 434, EE 464, Research	Excellent	Good	3 Optic Tables 10 Lab Benches	1064
2E6	Electrical Circuits & Systems: EE 231	Excellent	Excellent	12	1008
2E8	Electrical Signals & Systems: EE 215	Excellent	Excellent	12	1008
2E10	Electrical Signals & Systems: EE 215	Excellent	Excellent	12	1008
2E35	Communications & Electromagnetics: EE 434, EE 443, EE 444, EE 447, EE 448, EE 485, EE 387	Excellent	Excellent	10	1064
2E48/A	Computer Systems: EE 382, EE 383, EE 464	Excellent	Excellent	38	1904
2-6D	Design Techniques & Project; EE 463, EE 464	Excellent	Excellent	7	318
2F2	Design Techniques & Project: EE 463, EE 464	Excellent	Excellent	5	224
2F4	Design Techniques & Project: EE 463, EE 464, EE 495	Excellent	Excellent	11	696
2F44	Introduction Digital Systems: EE 281, EE 382	Excellent	Excellent	24	924
2F50	Electrical Power Systems: Engr 311	Excellent	Excellent	18	924
2G2	Instrumentation—Design: EE 360, EE 472, EE 463, EE 464	Excellent	Excellent	8	532
2G6	Electronic—Design Project: EE 321, EE 322, EE 473, EE 463, EE 464	Excellent	Excellent	18	1120
2G8	Anechoic Chamber—Microwave: EE 443, EE 444, EE 464, Research	Excellent	Excellent	6	952
2G24	Electronic Circuits: EE 321, EE 322	Excellent	Excellent	16	1120
2G26	Electronic Circuits: EE 321, EE 322	Excellent	Excellent	13	880
2G28A	VLSI Laboratory: EE 495, EE 464, Research	Excellent	Excellent	1	210

6.3 Modern Engineering Tools

Throughout our courses, many modern engineering tools are used to give cadets experience and proficiency. Software packages include numerical analysis programs, assembly language and C programming compilers as well as circuit simulation, layout, and routing programs. Hardware includes microcontrollers, real-time digital signal processing boards, logic analyzers, oscilloscopes, spectrum analyzers, signal generators, and a fully functional anechoic chamber.

Every required course and nearly every elective course in the program makes use of one or more programs for simulation, analysis, design, or testing of designs. Table 17 gives a detailed list of the software and software used in electrical engineering courses. The most commonly used analog and digital circuit simulation program is PSpice, used in the required courses El Engr 231, 281, 321, 322, 332, 463, 464, and 473. Programming practice is achieved through several required courses:

- Comp Sci 110, Introduction to Computer Science, where cadets are introduced to ADA programming techniques;
- Astro 320, Introduction to Astronautics for the Engineer and Scientist, where cadets gain another high-level language programming experience in MATLAB;
- El Engr 332, 333, 434, 447, and 448, where MATLAB programming is used extensively for analysis and design; and
- El Engr 382, Microcomputer Programming, and El Engr 383, Microcomputer System Design I, where cadets learn the fundamentals of programming in assembly language and C.

Table 14 lists these tools, the courses that use them and the depth of cadet experience expected in the course.

6.4 Lab Safety

Standard safety procedures are taught and enforced. Cadets are not allowed to wear jewelry in the lab, and a two-person policy for safety is the rule in all laboratories. Formal safety instruction is included in all introductory courses (El Engr 231 and El Engr 281) as well as the first lab intensive courses (El Engr 321 and El Engr 382). Written and verbal safety procedures are provided in El Engr 321, Engr 311, El Engr 444, and El Engr 464, which include a safety presentation at the beginning of the course. Several exercises in Engr 311 involve potentially hazardous voltages. The cadets are briefed at the start of these exercises and their work is constantly monitored by instructors and technicians. El Engr 444 instructors carefully monitor safety procedures while working with waveguide equipment and antennas. In all courses, cadets found violating prescribed safety procedures are dismissed from the lab.

The Dean of the Faculty and all departments have assigned safety officers who are responsible for ensuring conformance with accepted safety standards in all laboratory, classroom, and office areas. Inspections are routinely conducted by these safety officers at all levels. Any discrepancies are reported, and corrective action is taken within a specified time. The safety officer for the Department of Electrical Engineering is Ms. Susan Elmore.

Table 14. Engineering Tools and Expected Cadet Experience Level

Course	Tools	Exposure	Experience Level
EE 215	Function generators, oscilloscopes, multimeters	2 labs and 6 in-class exercises	Fair
	DC Challenge (circuit simulation software)	Homework	Introductory
EE 231	Function generators, oscilloscopes, multi-meters	Integrated lecture/lab/demo	Good
	Math software (cadets' choice: MATLAB, Mathematica, MathCad)	Computer exercises and homework	Fair
	PSpice Capture (circuit simulation software)	Computer exercises and homework	Introductory
	DC Challenge	Homework	Introductory
EE 281	PSpice Capture (for digital applications)	Homework and Labs	Fair
EE 321/322	PSpice Capture	Homework and Labs	Excellent
	Function generators, oscilloscopes, multi-meters	Labs	Good
EE 332/333	MATLAB	Homework	Good
EE 382	Programming the 68HC12A4 micro-controller	Lecture and 9 labs	Excellent
	CASM Compiler (C and Assembly Language)	Every lecture, all 9 labs	Excellent
EE 383	68HC12B32 microcontroller	5 labs and final project	Excellent
	HP 1664A logic analyzer	22 lessons	Fair
	ICC12 C Compiler	5 labs & final project	Excellent
	PALASM (PAL Compiler)	3 labs and final project	Excellent
	PALs, GALs, use of ALL-11 Universal Programmer	15 exercises	Good
EE 434	MATLAB	Homework	Excellent
	Code Composer Studio (DSP Software)	Homework	Fair
EE 443	MATLAB	Homework	Good
EE 444	Microwave Network Analyzers, Anechoic Chamber	Integrated lecture/lab/demo	Good
	Antenna Analyzers, Spectrum Analyzers	Lecture	Good
	EZNEC 3.0 (RF Modeling software)	Lecture	Fair
	MATLAB	Lecture/homework	Good
EE 447/448	Signal Generators, Spectrum Analyzers	Lecture	Fair
	MATLAB	Homework	Good
EE 473	PSpice Capture and Layout	Lecture, design projects, homework	Excellent
EE 463/464	Circuit Board Fabrication	Lecture	Fair
	Soldering	Integrated lecture/demo	Fair
	PSpice Capture and Layout	Lecture, design projects, homework	Excellent
	MS Project (project management software)	Design project	Good
EE 495	Function generators, analog o-scopes, power supplies, audio analyzer, soldering	Labs and Final Design Project	Excellent

6.5 Computing and Information Infrastructures

6.5.1 Computer Facilities Available for Use in the Engineering Programs

The focus of the USAF Academy's academic computing is the USAFAnet local area network (LAN). USAFAnet connects a personal computer (PC) at each cadet's dormitory desk to other USAF Academy computer resources by a fiber optic LAN system. The cadets' personal computers are used whenever possible for course work. Certain courses require capabilities exceeding the personal computers and a full array of supermini and workstation computer resources are also available through the 10th Communications Squadron and the individual engineering departments.

In order to connect to the USAFAnet LAN, each cadet, starting with the class of 1990, have been required to purchase a personal computer upon entry into the USAF Academy. The cost of the personal computers issued to each cadet is deducted from the cadet's pay and it is the cadet's property upon leaving the Academy. The standardized configuration and software of the computers allows faculty to plan and administer courses with the assurance that each cadet has a known set of computer resources at his or her personal disposal. On-site warranty for parts is provided by the manufacturer and maintenance is through a third party maintenance contract. A five-year history of cadet computers is presented in Table 15.

Table 15. Cadet Computer Purchase History

	Class of 2002	Class of 2003	Class of 2004	Class of 2005	Class of 2006
Make	Applied Computer Tech	Dell WS-210	Dell WS-220	Dell Latitude C600	IBM T-30
Type	Desktop	Desktop	Desktop	Laptop	Laptop
CPU	Pentium II	Pentium III	Pentium III	Pentium III	Pentium IV
Speed	350 MHz	450 MHz	733 MHz	850 MHz	1.4 GHz
RAM	64 MB	128 MB	128 MB	256 MB	256 MB
Hard Drive	6.5 GB	13 GB	20.4 GB	20.4 GB	40 GB
Other	-TV card -ATI video card -CD ROM drive -DVD drive -Ethernet card	-TV card -ATI video card -CD ROM drive -DVD drive -Ethernet card	-TV card -ATI video card -CD ROM drive -DVD drive -Ethernet card	-ATI video card -DVD/CDRW combo - Ethernet card	-ATI video card -DVD/CDRW combo -Integrated Ethernet card

The USAFAnet computer network provides services to each cadet's dormitory room using Windows NT Server 4.0 and Windows Server 2000 software. Wireless access points are being installed in the cadet library and throughout the Fairchild Hall academic buildings, and the Class of 2006 will be the first class to receive wireless network cards.

Network users have access to the Internet, electronic mail, bulletin boards, retrieval systems, laser printers, and disk drives for sharing or exchanging files. Gateways also connect USAFAnet to other colleges and universities, military and government installations, the Defense Data Network, and the Internet. Since its initial installation, USAFAnet has been expanded to all offices on the Academy (over 8,000 users) providing connections that reach all the faculty personal computer systems as well as laboratory, athletic, and administrative functions throughout the cadet area.

The Fiber Distributed Data Interface (FDDI) backbone of USAFAnet allows large amounts of data to be transmitted simultaneously, including digitized video and audio files. This fiber optic backbone provides throughput in the Gigabyte range. Controlled television signals can be viewed on the computer monitor at each cadet's dormitory desk. For juniors and seniors, these signals are sent to their computer's TV-card via Falcon Vision, a closed circuit TV network. For the classes using laptops (freshmen and sophomores), internet protocol video technology is used to view Falcon Vision. Programs using the video capabilities include additional academic instruction in a computer-controlled environment.

The USAFAnet or User Services systems include 80 Windows-based servers and two Unix-based servers. Maintenance of the network, the network interface devices, and the supporting computers are provided by the 10th Communications Squadron personnel as part of the Academy operating budget.

In conjunction with USAFAnet and the Academy-wide services provided by the 10th Communications Squadron, each engineering department maintains computer laboratories and software. The department computers support course administration and research by the faculty and directly support cadet laboratories and computer oriented courses. This support typically is in the form of data acquisition and analysis or design and simulation. A secondary use of department computers is the administration associated with the operation of the departments. Over 250 of the 300 classrooms are equipped with over-head one-gun projectors for displaying high quality video images of computer output, VCR, or TV signals in the class.

The cost of computer use and maintenance for 10th Communications Squadron hardware is included in the overall operating budget of the USAF Academy. New hardware must be budgeted for eight years in the future and competes on an as-needed basis with other equipment purchased by the USAF Academy. Software for 10th Communications Squadron is purchased in an on-going manner, with money budgeted each year for improvements.

6.5.2 Services Available to Assist Cadets and Faculty

A standardized set of hardware and software is owned by the cadet and retained upon graduation. While the software has varied slightly over the past four years, it generally includes the following or equivalent products:

MS-Windows	MatLab	AutoCAD
MS-Office Pro	MathCAD	AdaGIDE
Adobe Acrobat	Mathematica	

There are several other software packages which may be installed on each computer under a site license. This software is intended to be used by the cadets for their course work. These software packages are to be removed from the computer upon the cadet's departure from the USAF Academy.

In addition to operating and managing the USAF Academy's computer systems, the 75 personnel of the 10th Communications Squadron Support Flight provide an extensive array of consulting and maintenance services to cadets, faculty, and staff. Walk-in, telephone, and e-mail support is provided to anyone requesting assistance with a personal computer or one of the other systems. Numerous courses are taught on pertinent software packages and their use in the Academy's USAFAnet environment. The 10th Communications Squadron Support Flight provides a single point of contact for the reporting of any computer-related maintenance problems. Both extensive in-house and contract maintenance are available on both a standing and as-required basis.

6.5.3. Accessibility of Computer Facilities and Services

All computer facilities linked to USAFAnet, including the cadet and faculty personal computers, are accessible 24 hours a day except during scheduled maintenance on the network. With each cadet owning a personal computer, the access by cadets to the USAF Academy's computing facilities is excellent. Other selected nodes, such as the Sun systems, are also accessible via telnet 24 hours a day.

Access to the 10th Communications Squadron facilities provided through USAFAnet is unlimited, with all cadets and faculty having an account. However, on selected nodes used heavily by academic classes, restricted account numbers for cadets enrolled in the class are issued by the 10th Communications Squadron after an instructor has requested an account for a class. For all academic classes, these accounts have unlimited time. All cadet accounts are monitored and logged by user account and time, but there is no billing for time to the cadet, class, or instructor.

7. Institutional Support and Financial Resources

Institutional support, financial resources, and constructive leadership must be adequate to assure the quality and continuity of the engineering program. Resources must be sufficient to attract, retain, and provide for the continued professional development of a well-qualified faculty. Resources also must be sufficient to acquire, maintain, and operate facilities and equipment appropriate for the engineering program. In addition, support personnel and institutional services must be adequate to meet program needs.

7.1 Adequacy of Institutional Support, Resources, and Constructive Leadership

As noted in our mission statement, the USAF Academy is dedicated to cadet education and continually ensuring the resources required to accomplish this mission are available. As such, a well-defined process is in place to ensure each department and agency is allotted resources as dictated by the Dean of Faculty manning model (an algorithm to allocate people to departments based on the number of cadets and courses taught). The Department of Electrical Engineering works directly with the Engineering Division to ensure the necessary funds are available to accomplish its mission. Table I-5, *Support Expenditures*, in Appendix I-A, highlights our level of support from USAFA over the recent years.

7.1.1 Institutional Support

Institutional support is excellent. Besides a solid financial backing, the USAF Academy provides outstanding facilities, top-notch instructors, excellent support personnel, and a commitment to academic excellence. The former resources will be addressed in the following paragraphs; the latter is addressed here. The USAF Academy is a very unique institution in that the cadets are required to not only excel in academics, but they must also allocate time for mandatory military training and education as well as mandatory physical education and intramural athletics. It would be easy for one mission element (academics, athletics, or military training) to ask the cadets to dedicate a disproportionate amount of time to their element. USAFA understands this potential risk and closely monitors this situation. As a result, the cadets receive the necessary academic time they deserve. The support and leadership provided for the Department of Electrical Engineering by the institution, the Dean of the Faculty, and the Engineering Division has been sufficient to permit the department to meet the program's goals and outcomes.

7.1.2 Financial Resources

The United States Air Force Academy is a military service academy with a high priority in funding supported directly by the Department of the Air Force under the US Government's Department of Defense. The Department of Electrical Engineering's operating expenditures (salaries, classrooms, laboratories, computing equipment, communications support, etc.) are provided through government funds. Research, grant, and gift funds primarily support research work, supplemental cadet and faculty development, and enrichment support (e.g., field trips, cadet participation in IEEE student conferences).

Early each calendar year, the department's Director for Resources solicits inputs from the division chiefs regarding required funding for the coming year. Funding requirements for each course are provided by Course Directors and each electronics technician provides inputs regarding requirements to maintain and upgrade laboratories. Division chiefs consolidate this information to produce a detailed funding document which identifies required funding to meet course objectives and the impact if funding is not provided at the 100% level. These data are assembled by the Director for Resources into a financial plan and forwarded to the Department Head for approval. Once approved, the financial plan is sent to the Dean of the Faculty for funding.

To date, the funding for the Department of Electrical Engineering has been more than adequate to ensure we meet our program objectives. As part of our budgeting process, each course and laboratory indicates which objectives will be impacted if a budget cut is necessary. Fortunately, a budget cut has not been required for several years.

7.1.3 Facilities and Equipment

Currently, Fairchild Hall, the central academic building, is being renovated to include office, laboratory, and classroom upgrades. When completed, the renovation will provide better academic environments; thereby improving the opportunity for attainment of program educational outcomes.

The Dean of Faculty has a baseline of $864K/year for equipment that costs under $100K (capital equipment). To facilitate an equitable distribution of resources, each department completes a survey for new and replacement equipment. This survey specifies how often the equipment is used, the number of cadets who use it, whether or not it is used for research, safety information, and an impact statement if the equipment is not approved for purchase. In the case of equipment replacement, photos of current and recommended equipment are included. This information is submitted to the Dean of Faculty Equipment Allocation Board. This board objectively prioritizes all faculty requests for new and replacement equipment.

The Department of Electrical Engineering's expendable budget (for consumables such as resistors, microprocessors, and other electronic and supply consumables) is $100K per year. The submission format for these supplies is standardized across departments and includes a justification. This provides a completely defendable prioritization that is rarely disputed, so all needed funds have been provided.

In addition to our Program Operational Goals for our graduates, the Department of Electrical Engineering has developed a supporting goal to "*Acquire and maintain required budget, facilities, and equipment to meet our mission*" which is measured through the attainment of the following objectives:

- *Each course director will provide an annual forecast of course resource requirements.*
- *Each division chief will maintain a short-term (annual) and long-term (seven-year) resource requirements plan for his or her assigned division's curriculum.*

The Department will

- *Vigorously strive to obtain the required budget to meet our goals and objectives.*
- *Maintain appropriately equipped, cutting-edge laboratory facilities.*
- *Maintain cutting-edge computational facilities for use by faculty, staff, and cadets.*

Inputs from individual Course Directors and Division Chiefs allow the Department of Electrical Engineering Director for Resources to maintain a consolidated list of expendable and capital equipment needs. The Resource Director has been able to obtain the required budget to meet program goals and objectives by providing hardware and software sufficient for the needs of the faculty and cadets. The department has typically received the top three equipment items requested and has never gone without a piece of equipment required to fulfill program objectives.

Computer requirements are handled separately. There is a standardized Computer System Requirements Document that is submitted for computer systems. The Class of 2005 and subsequent classes will buy a centrally procured, local area network capable, laptop computer upon the start of the academic year. The USAF Academy has a four year replacement cycle for office and laboratory computers.

7.1.4 Constructive Leadership

Leadership at the USAF Academy, as well as within the Department of Electrical Engineering, stems from a well-defined and proactive military chain of command common to all military organizations. The Superintendent, a three-star general who reports directly to the Chief of Staff of the Air Force in Washington, D.C., serves as the overall commander of the USAF Academy. The Superintendent receives input from numerous sources including the Dean of the Faculty, a one-star general who reports directly to the Superintendent. The Dean of the Faculty, in turn, receives input from the department heads who report directly to him. The senior-ranking department head in an academic division serves as that division's chair. Colonel Cary Fisher, the Head of the Department of Engineering Mechanics, acts as the Chair of the Engineering Division which is comprised of five departments. This position is equivalent to the "Dean of the College of Engineering" at a civilian institution.

This leadership model contributes to achieving program objectives in many ways, including actively seeking feedback. For example, the Dean's annual Organizational Climate Survey, serves as the cornerstone of a closed-loop assessment of faculty and staff opinion. In addition, department-level leadership tools include annual performance reviews, annual formal course reviews, cadet course critiques, regularly scheduled staff and department meetings, and an annual off-site meeting for training and professional development.

7.2 Resources for a Well-qualified Faculty

The Dean of the Faculty manning algorithm used to allocate faculty slots to departments based on enrollment is expected to compensate for the enrollment increase in the next 12-24 months (a typical delay for this personnel model). This algorithm determines the number of faculty positions available to each department.

In addition to our Program Operational Goals for our graduates, the Department of Electrical Engineering has developed a supporting goal to *"Recruit, develop, and enrich faculty and staff of the highest caliber*" which led to a set of faculty centered objectives listed below:

- *Each faculty member will be encouraged to*
  - *Perform a balanced, manageable workload in an excellent manner.*
  - *Maintain technical and educational competence.*
  - *Attend at least one symposium/conference per year.*
  - *Actively pursue academic promotion.*
  - *Belong to and participate in at least one appropriate professional society.*
- *Department leadership will*
  - *Be aware of and support appropriate faculty and staff aspirations and goals.*
  - *Provide continuing professional development and research opportunities for faculty and staff.*
  - *Strive to continuously improve the organizational climate.*
  - *Maintain a long-range recruitment plan*.

Each of these objectives is discussed in the following sections.

7.2.1 Resources to Attract Faculty

Historically, the Department of Electrical Engineering has never had a problem attracting well-qualified faculty. We actively recruit the best military instructors the Air Force has to offer. Our recruiting activities include advertising on our internet website, advertising on the Air Force Personnel Center's (AFPC) website, and in magazines to attract our civilian professors. Many applicants have cited the department's internet site as their source of information and the Director for Personnel will continue to work with the department's WebMaster to keep the site updated.

The Director for Personnel maintains a spreadsheet with projected openings and incoming faculty members which is reviewed at least once a semester by the Deputy for Operations, Deputy Department Head, and Department Head. The Personnel Director also maintains a list of interested and qualified military personnel and contacts them when an opening is available. If this list becomes too small, the Air Force Personnel Center provides a list of all personnel with advanced degrees in electrical and computer engineering. The Director for Personnel contacts viable candidates to enlarge the selection pool. The Deputy Department Head maintains a list of interested civilians and is in charge of advertising and selecting personnel to fill civilian openings when they occur.

7.2.2 Resources to Retain Faculty

Military members are assigned to the USAF Academy for a minimum three-year controlled tour. Military members returning from a sponsored Ph.D. program are on a four-year controlled tour. A few military members are also offered a sequential tour meaning they may stay another four years after their first tour has ended. Civilian professors are employed on a renewable contract with a period of between three to five years.

Retaining faculty within the Department of Electrical Engineering is rarely a problem. Nevertheless, we take every effort to ensure our faculty are content in their assignments. We solicit their inputs at least once a year to determine how to best meet their needs. We give them a voice in what they teach, additional duties, and professional development.

A balanced workload is assigned by the Deputy for Operations with the assistance of the division chiefs. Instructional excellence is measured by cadet critiques, faculty observations, and supervisor's observations. The department standard is for instructors and overall course scores to average at least 4.0 (slightly agree) on cadet critiques. The Trusted Agent and Department Head work with instructors who do not meet these levels to improve their instruction. The Trusted Agent and Division Chiefs meet with the Course Directors to develop "get well" plans for the courses with less than a 4.0 overall score. Academic promotions are highly encouraged and during the last six years, we have had ten instructors seek and obtain the next higher academic level. Currently 94% of the faculty (16 of 17) belong to at least one professional society and have at least a low level of participation throughout the year.

The Dean of Faculty Organizational Climate Survey is administered and reviewed every year. Results are deemed adequate if the department averages at least 4.0 (Slightly Agree) on faculty responses. The Department Head reviews numerical results and trends. He specifically addresses all written comments and downward trends at the annual back-to-school offsite. Where concerns could be addressed by the department, the actions to be taken to resolve issues are presented and discussed.

7.2.3 Resources for Continued Professional Development of Faculty

Department leadership performs at least annual feedback sessions with all instructors to review their goals and performance. Professional development is consistently encouraged by advertising all Center for Educational Excellence workshops, providing funds for symposia and conferences, requiring attendance at departmental Noon Information and Brown Bag Lunch Educational Seminars (NIBBLES), providing work units for requested research, and providing technical training for technicians. The Academy's Center for Educational Excellence runs a comprehensive system of seminars on topics such as learning styles, teaching techniques, examination writing, active learning, the use of technology in the classroom, etc. Whereas all faculty members are encouraged to attend these on-site lunchtime seminars, we mandate attendance at a minimum number of seminars for new faculty. The department's Faculty Development

Officer serves as the focal point for disseminating news about, and encouraging participation in, these seminars.

Funds are programmed into the department's annual travel budget to support at least one professional development activity such as a short course, conference, or workshop per year for every member of the Department. This includes military and civilian faculty, electronics technicians, and administrative support personnel. In addition, each instructor is required to attend lunch-time presentations by fellow faculty members and support personnel are invited to attend. These presentations typically discuss research performed by the faculty. Some presentations are to instruct members of the department on the proper use of software and/or equipment.

The Faculty Observation Program has two goals, one for individual performance evaluation purposes and the other for faculty development. For evaluation purposes, the goal is to have every instructor visited at least once a semester by supervisors. For faculty development purposes, the goal is to have every instructor observe another instructor at least once. The implementation of this program is constantly evolving to get maximum participation and shows an increase every year.

Faculty members are also encouraged to participate in IEEE and American Society of Engineering Educators (ASEE) conferences, technical committees, and to hold leadership positions. Department members are currently involved in multiple technical committees and both regional and national leadership positions.

The Air Force Academy also provides some unique professional development opportunities not available at most universities. Faculty members are encouraged to serve as academic advisors to cadet squadrons, as professional ethics advisors, and as officer representatives to intercollegiate or club sports teams. In addition, during the summer, faculty are encouraged to fill leadership positions in the cadet military training activities.

7.2.4 Potential Concern for Military Faculty Manning

An area of concern is the potential non-availability of military officer-engineers in the coming years. The United States Air Force is critically short of active duty officer engineers. Currently the Air Force is only 60% manned in the engineering career field, i.e., the Air Force is over 800 engineers short of requirements.

Due to recent USAF policy in response to this shortage, we are concerned we will be unable to continue to fill our military engineering faculty slots. Specifically, the Air Force plans to temporarily reduce, through attrition of our younger USAF officers, the Department of Electrical Engineering from its current military manning of 13 faculty members (out of 17 total faculty members) to as few as nine (9) military members within the next two years. That is, our current active duty USAF officer engineers, once reassigned to other Air Force engineering positions, will not be replaced until the USAF engineering manning improves.

The Department of Electrical Engineering desires to maintain the quality of the electrical engineering program due in part to the low cadet – faculty ratio and the quality of faculty research contributions to both the cadets and the Air Force. We anticipate funds will be available to hire additional civilian term faculty to replace a good portion of the loss of the active duty USAF officers. However, we also desire to maintain a predominantly military-officer engineer faculty to serve as military role models and military career counselors.

7.3 Adequacy of Support Personnel and Institutional Services

7.3.1 Support Personnel

Support personnel at the USAF Academy that directly impact the Department of Electrical Engineering's mission include the department's electronics technicians, the Engineering Division Laboratory (formerly the Engineering 410 lab), and the Dean of Faculty Support Squadron Training Devices personnel. The technicians are highly trained individuals with a very strong work ethic. They are skilled at working with cadets to turn design concepts into a working system and are invaluable members of the department. In fact, they are hired against stringent requirements including excellent communication skills. As previously stated, everyone is encouraged to attend professional development activities. The technicians are certainly no exception. They attend workshops and seminars throughout the year to either increase their knowledge or learn a new tool (software or hardware) or development system. The Department of Electrical Engineering also gets equipment support from an on-site Precision Measurement Laboratory.

The Engineering Laboratory is staffed with experts in the respective fields. They instruct cadets on the proper use of machinery such that cadets are able to complete their projects (typically a senior design project). If the task requires more skill than the cadet possesses, the technicians in these organizations will actually perform the work for the cadet. They have always provided outstanding support to our cadets, staff, and faculty.

7.3.2 Library

The Academy Library collection consists of over 1.5 million items used in the library or checked out from numerous collections. The computerized cataloging and reference system may be accessed by all instructors and cadets either throughout the library or via the local area network. These resources include full-text journals, librarian-selected web sites, and a host of other databases useful to university-level researchers and cadets in all academic disciplines. There are over 350 key science and engineering periodicals. Finally, a complete interlibrary loan and document delivery service exists for all faculty and cadets, making the library one of the best undergraduate research facilities available. There is also a Special Collections Branch which has some of the best collections of aviation items in the world.

7.3.3 Directorate of Education and the Center for Educational Excellence (CEE)

The Center for Educational Excellence is a part of the Dean of Faculty's Education Division. The center's vision is to help transform the USAF Academy's educational system into a cooperative, cadet-centered, active learning environment that values the development of the Dean of the Faculty's Educational Outcomes in each cadet. The center's mission is to support the USAF Academy faculty in their efforts to enhance cadet learning by offering state-of-the-art services in faculty and curriculum development, educational technology, research, and assessment. The Center for Educational Excellence offers a host of services including the following:

- Faculty Orientation. A comprehensive 20-hour program for new and returning faculty.
- Faculty Development Workshops to strengthen instructors' teaching and professional skills through one-to-three hour sessions in various topic areas.
- *The USAFA Educator*. A quarterly newsletter with contributions from across the faculty.
- A centralized Library where faculty may check out books and articles.
- Faculty Interest Groups. A forum for discussions on topics of interest.
- Faculty/Cadet Multimedia Lab for faculty and cadets. Used to create effective classroom presentations.
- Network Classroom Laboratory. Available to the entire faculty.
- Individualized Teaching/Learning Consultations which afford faculty members the opportunity to get researched-based suggestions.
- Centralized Assessment Resources. Focal point for accreditation documentation for the institution and all accredited program. Also helps course directors and instructors develop plans and gather and analyze data on course and program effectiveness. Maintains a USAF Academy assessment catalog.
- Software Support. Computer software expertise to help faculty members find, evaluate, and implement off-the-shelf educational software solutions.

7.3.4 10th Communications Squadron

The 10th Communications Squadron is dedicated to providing cadets, faculty, and support personnel with outstanding communications, information systems, and services for the education, training, and support mission of the Air Force Academy. Specifically, they provide and maintain the communications and computing infrastructure of the Academy including telephone management, network control, help desk, database management, personal computer maintenance, as well as photographic, illustration, television, and video support.

7.3.5 Training Devices

Resident within our academic building is an organization responsible for taking the educational design experience out of the classroom and into reality. The Dean of Faculty Support Squadron Training Devices organization supports USAFA by fabricating (or teaching cadets how to fabricate) projects designed in the classroom. Fabrication techniques are not limited to simple wooden structures; these highly skilled technicians are well versed in all modern fabrication technologies and associated machinery. This organization provides an invaluable service to the faculty by showing the cadets that design is just one problem to be solved in the development of a product. Cadets are exposed to the real-world problems associated with engineering, prototyping and model-making.

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8. Program Criteria

The structure of the curriculum must provide both breadth and depth across the range of engineering topics implied by the title of the program. The program must demonstrate that graduates have:

a) knowledge of probability and statistics, including applications appropriate to the program name and objectives

b) knowledge of mathematics through differential and integral calculus, basic sciences, computer science, and engineering sciences necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components, as appropriate to program objectives.

c) knowledge of advanced mathematics, typically including differential equations, linear algebra, complex variables, and discrete mathematics.

The *required* component of the electrical engineering curriculum combines a tightly integrated set of courses designed to provide a solid theoretical foundation in the principles of electrical engineering and practical application of these principles through laboratory experience. For the hands-on component of the curriculum, the Program Curricular Outcomes place emphasis on the development of problem-solving, written and oral communication, and experimentation skills. With few exceptions, design, computer-aided engineering, and the laboratory experience are woven throughout the required electrical engineering program to prepare cadets for their senior design project courses (El Engr 463 and 464).

The *elective* component of the curriculum offers cadets the opportunity to explore a variety of advanced electrical engineering topics in depth. Cadets may select from five areas of concentration: electronics, computer systems, communications, control theory, or a "universal" option that allows cadets to take any two electrical eEngineering options. Cadets may also participate in research through El Engr 499 Independent Study, or enroll in El Engr 495, Special Topics, offered nearly every semester. For the past six years, El Engr 495 offerings have included Optics, Digital Signal Processing, and Audio Amplifier Design.

8.1 Program Breadth

Required courses in the electrical engineering program incorporate topics in electrical circuits, digital systems, electronics, power systems, continuous and discrete time systems, electromagnetics, and communications systems. Some topics, such as electrical circuit analysis, are emphasized in several required courses. Other topics, such as microcomputer programming, are covered primarily in a one-semester course.

Each division within the Department of Electrical Engineering (Computer Systems, Electronic Systems, Signals and Systems, and Communications) is responsible for ensuring that required topics are appropriate to the electrical engineering discipline, based on the experience of division members in their areas of expertise. The sequence of topics is reviewed at the annual Division Briefs and summarized in the annual Division Reports. Course content and topic sequences are also reviewed by the entire electrical engineering faculty at the course briefs given before each offering.

The following list shows how the topics in the required courses of the electrical engineering program ensure breadth. (NOTE: El Engr 463, Design Project Techniques, and El Engr 464, Design Project, typically involve several or all of the following topics):

Electrical Circuits:
El Engr 231 - Electrical Circuits and Systems I
El Engr 332 - Electrical Circuits and Systems II
El Engr 333 - Continuous-Time Signals and Linear Systems
El Engr 321 - Electronics I
El Engr 322 - Electronics II
El Engr 443 - Electromagnetics
El Engr 447 - Communications Systems I
Engr 311 - Electrical Power Systems

Digital Systems:
El Engr 281 - Introductory Digital Systems
El Engr 382 - Microcomputer Programming

Electronics:
El Engr 321 - Electronics I
El Engr 322 - Electronics II

Power Systems:
Engr 311 - Electrical Power Systems

Continuous-Time Systems:
El Engr 231 - Electrical Circuits and Systems I
El Engr 332 - Electrical Circuits and Systems II
El Engr 333 - Continuous-Time Signals and Linear Systems
El Engr 447 - Communications Systems I

Discrete-Time Systems:
El Engr 434 - Discrete-Time Signals and Systems

Electromagnetics:
El Engr 443 - Electromagnetics

Communications Systems:
El Engr 231 - Electrical Circuits and Systems I
El Engr 447 - Communications Systems I

Laboratory Procedures:
El Engr 231 - Electrical Circuits and Systems I
El Engr 281 - Introductory Digital Systems
El Engr 311 - Electrical Power Systems
El Engr 321 - Electronics I
El Engr 322 - Electronics II
El Engr 382 - Microcomputer Programming
El Engr 443 - Electromagnetics
El Engr 447 - Communications Systems I
El Engr 463 - Design Project Techniques
El Engr 464 - Design Project

8.2 Program Depth

The fact that the "breadth" requirement is met by this program is seen by examining the coverage of topics in the listing above. "Depth" in at least one area is ensured by the required selection of elective courses in an area of emphasis. Five recommended elective sequences are described in the 2002 - 2003 Curriculum Handbook, providing study in the following areas:

- Electronics - This area of study provides a general foundation in all areas of electrical engineering. The emphasis is on electronic design, components, and applications. It is well suited for those who want to retain the flexibility to work and/or do graduate studies in electrical engineering, physics, medicine, or other technical fields.
- Communications - Classes in this area of study are the basis for understanding modern radar and communication systems. Topics include: fiber optics, modulation techniques, radio components, and antennas. Study in this area leads to a better understanding of satellite communications and systems, telephones, stealth technology, and advanced radar systems.
- Computer Systems - In this area of study, the fundamentals and advanced concepts of computer design are explored. Topics include microcomputers, system design and interfacing, and computer architecture. Classes in this area of study lead to a better understanding of modern computer systems and digital hardware design.
- Controls - This area of study consists of up to four (4) courses taught by the Department of Astronautics. The analysis and design of automatic control systems is emphasized. Control systems are integral components of modern society, from a simple thermostat to space vehicles.
- Universal Area - Cadets are free to choose two courses from the approved elective options below to fulfill the electrical engineering major's elective requirements. These electives, along with the Engineering/Basic Science Option, provide the opportunity to "pick and choose" classes that are of interest.

Each course in an area of emphasis sequence is designed to provide advanced study of at least one area of electrical engineering. Thus, since all electrical engineering majors must take a minimum of two electrical engineering electives from the list below, all obtain a depth of knowledge no matter what electives they choose.

Electrical Engineering Electives (by area of emphasis):

Digital Systems

El Engr 383 - Microcomputer System Design I
El Engr 484 - Microcomputer System Design II
El Engr 485 - Computer Architecture

Electronics

El Engr 473 - Introduction to CMOS VLSI Circuit Design
El Engr 495 - Audio Amplifier Design

Electromagnetics

El Engr 444 - Applied Field Theory

Communications Systems

El Engr 448 - Communications Systems II

Control Theory

El Engr 387 - Introduction to Robotic Systems
Engr 341 - Linear Systems Analysis and Design
Engr 342 - Linear Control System Analysis and Design
Astro 443 - Digital Control Theory and Design
Astro 444 - Modern Control Theory and Design

Electrical engineering majors also have an opportunity to pursue depth of study at an advanced level through periodic offerings of El Engr 495, Special Topics, and El Engr 499, Independent Study.

All cadets have one Engineering/Basic Science Option which should be chosen from the following list of courses:

Aero Engr 341 - Fluid Dynamics
Biology 330 - Basic Biological Science I
Biology 345 - Aerospace Physiology
Chemistry 233 - Organic Chemistry I
Chemistry 335 - Physical Chemistry I
El Engr 495 - Special Topics (with Department Head approval)
El Engr 499 - Independent Study (with Department Head approval)
Engr 434 - Small Spacecraft Engineering II
Engr Mech 320 - Dynamics
Engr Mech 340 - Materials Sciences for Engineers
Mech Engr 390 - Automotive Systems Analysis
Physics 264 - Modern Physics
Physics 391 - Introduction to Optics and Lasers
Physics 393 - Solid State Physics
Physics 482 - Laser Physics and Modern Optics

Any 300- or 400-level Mathematics course (excluding Math 310 or Math 320) not used to fill any other requirements.
Any Electrical Engineering Option not used to fill another requirement.

Electrical Engineering majors are also highly encouraged to take Engr 402-Professional Engineering Development, and to take the Fundamentals of Engineering exam.

Table 16 shows the suggested course sequence for electrical engineering majors. It is designed to balance their demanding majors courses with the core courses taken from the four Dean of Faculty divisions; engineering, basic sciences, social sciences, and humanities. An adjustment will be made to this recommended sequence for the Class of 2006 and beyond which will replace the senior level engineering design course (Engr 410) with a freshman level introductory engineering (Engr 100). The amount of core from the social sciences and humanities will also be reduced. The classes of 2003 and beyond will replace Engr 410 with an additional two semester hours in El Engr 463, Design Project Techniques. This provides a full six semester hour, year long design experience.

Table 16. Recommended Course Sequence

	Freshman	Sophomore	Junior	Senior
FALL	MSS 111 Chem 141 English 111 For Lang Math 141	Econ 221 El Engr 231 English 211 History 101 Math 243 Physics 215 Pol Sci 211	Aero Engr 315 Beh Sci 200 El Engr 332 El Engr 321 El Engr 382 Math 346	Astro 320 El Engr 463 El Engr 434 El Engr 447 El Engr Option* Engr 410 Engr/Bas Sci Option**
SPRING	Chem 142 Comp Sci 110 Engr Mech 120 For Lang Math 142 Physics 110	Biology 215 Civ Engr 210 El Engr 281 Engr 311 History 202 Math 245 Mgt 210	El Engr Option* or El Engr 443 El Engr 333 El Engr 322 Law 310 MSS 311 Math 356	El Engr Option* or El Engr 443 El Engr 464 English 411 MSS 411 Philos 310 Pol Sci 312

8.3 Mathematics and Applications

The electrical engineering program requires three mathematics courses (Math 243, 245, and 346) beyond the core (Math 141, 142, and 356) requirements for a total of 18 semester hours. Nearly all of the program-specific mathematics topics are covered in these courses, and are used in electrical engineering courses, as the Table 17 indicates (an "r" superscript following an electrical engineering course number indicates that it is required of all electrical engineering majors):

Table 17. Program Specific Mathematics Topics

Topic	Covered In Math Course(s)	Used in EE Course(s) Related to
Basic Calculus	Math 141 Math 142	Circuit and System Analysis (EE 231^{r} , EE 332 ^{r}, EE 333 ^{r})
Probability and Statistics	Math 356	Circuit and System Analysis (EE 434 ^{r}) Communication Systems (EE 447 ^{r}, EE 448) Advanced Computer Architecture (EE 485)
Linear Algebra	Math 245 Math 346	Circuit and System Analysis (EE 333 ^{r}, EE 434 ^{r})
Complex Numbers/ Variables	Math 141	Circuit and System Analysis (EE 231 ^{r}, EE 332 ^{r}, EE 333 ^{r}, EE 434 ^{r}) Electrical Power Systems Analysis (Engr 311 ^{r}) Communication Systems (EE 443 ^{r}, EE 444, EE 447 ^{r}, EE 448)
Numerical Analysis	Math 346	Circuit and System Analysis (EE 434 ^{r}) Communication Systems (EE 444)
Advanced Calculus Differential Equations	Math 243 Math 245 Math 346	Circuit and System Analysis (EE 333 ^{r}, EE 434 ^{r}) Communication Systems (EE 443 ^{r}, EE 444, EE 447 ^{r}, EE 448)
Partial Differential Equations	Math 346	Communication Systems (EE 443 ^{r}, EE 444)

8.4 Electrical Engineering Program at a Glance

The Electrical Engineering Program at the USAF Academy is designed to provide breadth and depth for each cadet. The instructional environment is ideal for effective cadet learning due to the small class sizes, excellent classroom and laboratory facilities, well qualified and enthusiastic faculty, and outstanding leadership. The program operational goals, curriculum, and program curricular outcomes have been validated and accepted by our constituency and are regularly reviewed. Cadets have many avenues for interacting with the faculty and the opportunity to provide feedback on their learning experience. An overview of the curriculum (required and elective) is shown below in Figure 7:

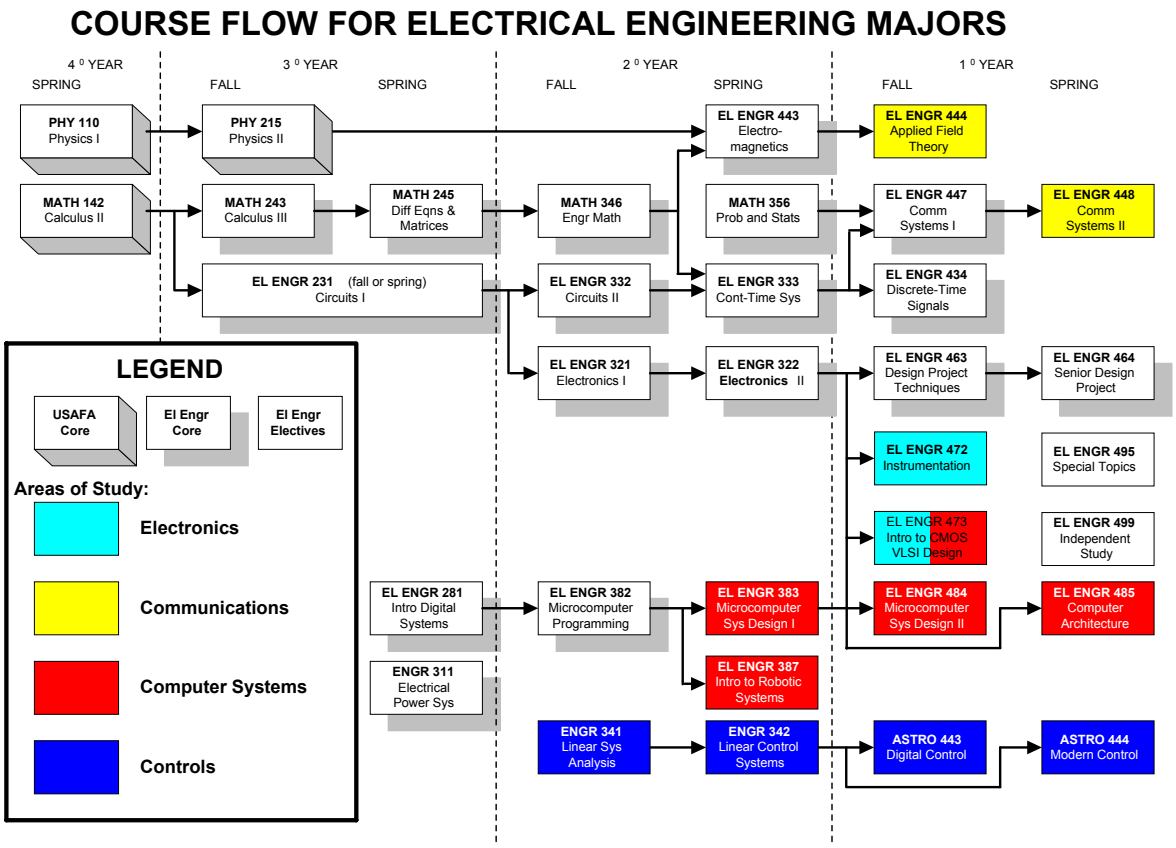

Figure 7. Course Flow for Electrical Engineering Majors

9. General Advanced-Level Program

Not applicable. No advanced level program accreditation is sought.

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